HEISHA Technology Workshop Customized Technical Framework White Paper

—A Customized Modular Technical Architecture for Drone docks

project	content
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Target Audience	System integrators and developers; customer-side structural engineers and electrical engineers
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Abstract

A UAV hangar is not a simple enclosure; rather, it is a mechatronic system that integrates structural, transmission, electrical, temperature-control, sensing, communication, and control functions. Its application scenarios range from polar scientific expeditions to coastal security, from mine-site inspections to logistics transfer, and from rooftop mobility to indoor warehousing. Environmental constraints and mission requirements vary dramatically, making it impossible for standardized products to provide comprehensive coverage; customization is therefore an inevitable choice. However, the traditional "design from scratch for each order" approach entails three costs: long lead times, high costs, and uncontrolled reliability.

For eight years, HEISHA has focused on a single objective: building houses for robots—avoiding complete solutions, avoiding full aircraft drones, and avoiding cloud-based business software; instead, it concentrates on the aircraft hangar platform itself and provides supporting services for solution providers. Within this scope, HEISHA has transformed aircraft hangar customization from "redesigning" into "modular combination," with its technical framework consisting of three components:

1、A six-layer technical architecture. All technical elements of the hangar are divided into six layers: L0 cabin structure, L1 transmission and actuation, L2 electrical power and energy, L3 control and sensing, L4 interface protocols, and L5 delivery and operations and maintenance. Layers are isolated through semantic interfaces, enabling a "change in the door transmission method" to be implemented without modifying the cloud-based protocols, thereby allowing faults to be localized and addressed layer by layer.

2、A three-dimensional modular system. All mechanical actions in the hangar are exhaustively categorized into three types: door actions (cabin door actuation), mobile actions (unmanned aircraft displacement), and active actions (functional operations); these are then packaged according to "actuation method × size class" into 69 module codes (MD01 – MD24, JD01 – JD24, ND01 – ND21), with the drawings and BOM integrated into the design documentation. In most cases, customized projects degenerate into table-based component selection and combination verification.

3、Unified interface protocol. All hardware capabilities are exposed externally via the MQTT Thing Model: 14 topic categories, a unified SERVICE+EVENT interaction model, a Modbus register mapping table, and a three-tier event architecture (INFO/ERROR/ALERT). All aircraft fleets share a single API, and all UAV models share a single API; the HSC cloud ingestion software and the DNEST scheduling platform provide their source code directly.

This framework is underpinned by verifiable engineering deliverables: 36 patents (with 18 patent rights maintained), a 44-line drone compatibility checklist, over 12 product variants, ISO 9001 and CE/FCC/CCC/RoHS compliance certificates, EMC and safety test pass reports, approximately 30 API version iterations, and a record of roughly 70 real-world engineering issues.

This document also provides the evidentiary level and scope of application for the data: product parameters, protocol fields, and certificate numbers are all taken verbatim from the currently available documentation on Heisha and are verifiable; engineering analysis and selection-based inferences are distinguished by terminology such as "engineering analysis" and "recommendations"; projects for which third-party measured data or commercial data support has not yet been obtained are collectively listed in Appendix E, "List of Data Pending Verification," and shall not serve as formal basis for selection.

Target Audience and Reading Guide

This article is intended for three types of technical readers; we recommend reading it according to the following sequence:

reader	Recommended path	Key Chapters
Integrators / Developers	Chapter 2 → Chapter 7 → Chapter 6 → Chapter 9	Chapter 7: Interface Protocols (particularly 7.4 Register Mapping and 7.9 Integration Guidelines); Chapter 6: 6.9 Software Product Line and Source Code Delivery
construction engineer	Chapter 2 → Chapter 3 → Chapter 5 → Chapter 9	Chapter 3: Three-Motion Mechanism (3.4 – 3.6) and Linkage Timing (3.8); Chapter 5: Environmental Adaptability; Chapter 9: RFI, Classes 2 and 3
electrician	Chapter 2 → Chapter 4 → Chapter 7 → Chapter 8	Chapter 4 Power Budget (4.4); Chapter 7 Register Scaling Rules (7.4); Chapter 8 EMC and Safety Testing (8.4)

Quick Search Guide:

"Find out which modules are needed for my requirements" → Chapter 3: Coding Table + Chapter 9: Selection Decision Tree

Want to know "how to integrate with my cloud platform"? → Chapter 7

Want to know "How to handle extreme cold, extreme dust, and coastal conditions"? → Chapter 5

Want to know "how to calculate power and where the electricity comes from"? → Chapter 4

"Want to know what evidence supports reliability?" → Chapter 8

"Want to know how the 'Know' project should be advanced and what requirements should be raised" → Chapter 9

Annotation Agreement

This article employs three levels of description for the nature of its content; no other markers are used throughout the text:

Verifiable facts—including parameters, model numbers, field names, enum values, certificate numbers, and patent numbers — shall be transcribed verbatim, with their timestamps, conditions, and scope constraints preserved;

Engineering analysis — introduced through phrases such as "from an engineering perspective," "this implies," and "it can be inferred" — constitutes a technical interpretation rather than an established conclusion;

Recommended content—introduced as "recommendations" —refers to the methods or framework proposed in this document; it does not constitute the current standards for HEISHA and shall be adopted only after undergoing technical review.

For a small number of projects for which actual measured or commercial data have not yet been obtained, the main text uses "—" to indicate this, and the items are listed item by item in Appendix E.

The principles for handling the nature of content in this article:

Verifiable facts (parameters, models, field names, enum values, certificate numbers, and patent numbers) are all displayed directly, while their timestamps, conditions, and scope constraints are preserved.

Engineering analyses are introduced with phrasing such as "from an engineering perspective," "this implies," and "it can be inferred"; they constitute technical interpretation rather than established conclusions.

Recommended content should be introduced as "Recommendation"; it represents the method or framework proposed in this document and does not constitute the current standards for HEISHA. Such content may be adopted only after undergoing technical review.

All protocol fields and code identifiers (topic names, method names, register names,

enum values) must be transcribed verbatim, including any spelling variations present (e.g., DOOR_EEROR_REG, confirm_rainall, "2-heating mode"), so that developers can use them directly for integration.

Data Boundary Declaration

1. The entire content of this document is based on information provided by Heisha. No external industry data have been used; information regarding market size, growth rates, shipment volumes, and other data for which no supporting information is available has not been included; parameters for which there is indeed no supporting data are denoted by "—" and are collectively listed in Appendix E, the Data Pending Verification List.

2. Quantitative data retain their original time, conditional, and scope constraints. Content marked as "optional," "special customization," or "customization accepted" shall not be presented in a more formal or elevated form in this book.

3. The certificate number, standard number, patent number, and test report number have all been transcribed verbatim from the original documents (including the results of image recognition from the certificates). Fields that cannot be identified in the images have not been inferred.

4. The materials contain several self-contradictory elements (such as the D200 power rating and the T-series status enumeration); in the relevant sections, these are presented side by side and accurately identified, without any one-sided omission or preference.

Table of Terms and Abbreviations

Terms/Abbreviations	definition
Door Motion (MD)	The transmission method for the hangar door. Whenever a hangar has storage functionality, this component must be custom-made. Code: MD01–MD24
motor-driven(JD)	The mobile mechanisms of a drone within its hangar (centering, translation, vertical movement, magazine deployment, etc.). In this book, "maneuverability"

Terms/Abbreviations	definition
	specifically refers to the drone's mobile mechanisms and does not refer to "maneuverability/flexible dispatch." Codes: JD01–JD24
active(ND)	For the functional actuation mechanisms of unmanned aerial vehicles (battery swapping, propeller replacement, hydrogen refueling, water refueling, pitch control, etc.): codes ND01–ND21
Three Movements	The collective term for manual, mechanical, and active operations; that is, the threefold classification of all mechanical actions in a hangar.
Size range	For the same transmission mode, the gear ratios are discretized by size; currently, there are three gears: large, medium, and small (see Section 2.3.3 for the quantitative definition).
T100	The main control board of the HEISHA crusher operates on embedded Linux; its integrated command interface is implemented as a local C program, allowing continued operation even when the network is disconnected.
T3	HEISHA Control Piles/Monitoring Piles (see D80 and D135 packaging lists)
HSC	HEISHA CLOUD SOFTWARE, Heisha Ruyun Middle Software, packages flight control commands or MSDK into an MQTT IoT model and delivers the source code.
DNEST	HEISHA One-Stop UAV Mission Management Cloud Platform (WEB +

Terms/Abbreviations	definition
	Android APP), source code delivered
QRPL	QR Precision Landing, including QRPL-M4E and QRPL-Mini
ACK	HEISHA Charging Management Module Series (ACK150 / ACK800 / ACK2000)
DCAP	HEISHA Vehicle Hangar Series (DCAP / PRO / MINI / LITE / INBUILT)
OSD	Attribute message reported by the fixed-frequency device (pushMode=0, 0.5 Hz)
state	Device attribute messages reported on demand (pushMode=1; triggered by status changes)
Push Mode	Data push mechanism: 0 = fixed frequency, 0.5 Hz; 1 = push whenever data changes; 2 = no active pushing; data is retrieved from the server
SERVICE / EVENT	The command issuance channel and the event reporting channel of the physical model are paired together to form an interactive closed loop.
step_key	A current-step identifier with a progress instruction, used to represent the execution sequence
INFO / ERROR / ALERT	Event Level 3: Normal Operation Notification / Non-fatal Fault / Fatal Fault
Modbus	Industrial serial communication protocols; this book covers both MODBUS RTU and MODBUS TCP variants.
MQTT	Message Queue Telemetry Transport Protocol: The protocol described in this book is based on MQTT 3.11.

Terms/Abbreviations	definition
MSDK / PSDK	DJI Mobile SDK / Payload SDK
MAVLINK	Open-source flight control communication protocols (PX4, ArduPilot, INAV, etc.)
RTK	Real-time dynamic carrier-phase differential positioning
IP(levels of protection)	Enclosure protection rating (GB/T 4208 / IEC 60529), such as IP54 or IP65
C4-M	Corrosion protection rating (marine/high-salt-fog environment rating under the ISO 12944 system); see D90
CCC	Midum mandatory product certification
CE / FCC / RoHS	EU Compliance / U.S. Federal Communications Commission / EU Hazardous Substance Restrictions
CNAS / ilac-MRA	Midum National Accreditation Service for Conformity Assessment / International Laboratory Accreditation Cooperation Organization Mutual Recognition Agreement
UPS	Uninterrupted Power Supply
PTC	Positive temperature coefficient heating element
RFI	Request for Information: Requirements Input List (see Chapter 9)
BOM	Bill Of Material

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catalogue

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Charpter 1 Industry Context and Customization Challenges

1.1 What is a UAV hangar, and what problems does it address?

1.1.1 function definition

A UAV hangar is ground-based infrastructure designed to provide storage, protection, charging/battery swapping, automated takeoff and landing, and remote control for unmanned aerial vehicles; its core objective is to enable unattended, autonomous operations. Heisha's product positioning is "building houses for robots" — this positioning elevates the hangar from a "UAV accessory" to a component of "robot ground infrastructure."

From an engineering perspective, a UAV hangar is not merely a simple box-shaped container; it is a mechatronic system that integrates seven categories of engineering elements:

Engineering Elements	function declaration	Corresponding technical layer
structure	Cabin load-bearing, sealing and protection, and installation and deployment	L0 Cabin Structure
transmission	Door opening and closing, centering and positioning, vertical and horizontal movement, and functional operations	L1 Drive Execution
electrical	Power supply management, charging compatibility, and energy distribution	L2 Electrical Energy
temperature control	Heating and cooling, constant-temperature control, and anti-condensation	L3 Control Perception
perception	Visual recognition, meteorological monitoring, and status data acquisition	L3 Control Perception
communication	4G/5G/Ethernet/Satellite/Dedicated Network/RS485	L4 Interface Protocol
control	Local logic, remote scheduling, fault linkage	L3/L4/L5

This means that the design complexity of the hangar far exceeds that of a typical outdoor enclosure; its engineering challenge lies in the coordinated integration of multiple systems and the verification of their reliability.

1.1.2 A complete unattended operation cycle

Taking the D90, a dedicated aircraft hangar for extreme cold and extreme dust

conditions, as an example, the operational execution chain is as follows:

Task issued via cloud platform (provided by the customer) → Hangar door opened → UAV takes off for aerial photography/inspection → Upon task completion, UAV automatically returns and repositions → Automatic charging → Hangar door closes

Within this cycle, the sequence of actions that the hangar must perform includes:

1. Instruction reception: Receive task instructions from the cloud or local scheduling platform via MQTT/MODBUS

2. Environmental assessment: Check whether the meteorological conditions (wind speed and rainfall), cabin temperature, and equipment status meet the takeoff requirements.

3. Door Opening: The door actuation module triggers the door opening and simultaneously releases the sealing lock.

4. Drone release: the mobile module completes the push-rod release or lifting operation, providing the drone with takeoff space.

5. Drone operations: drones perform aerial photography, inspection, logistics, and other tasks (this phase is handled by the flight control system and business software and falls outside the scope of the aircraft's responsibilities).

6. Return and alignment: The drone returns to the area above the hangar and completes a precise landing via visual or physical guidance.

7. Return-to-base positioning: The mobility module pushes the UAV to the charging station, ensuring that the charging contact points are properly aligned.

8. Automatic charging: Once the charging module is activated, it executes the fast-charging or slow-charging strategy based on the battery specifications.

9. Cabin protection: Once charging is complete or has exceeded the timeout, the cabin door closes, and the temperature control system maintains the cabin environment.

Of the nine steps described above, all except Step 5 are carried out by the hangar itself. Failure at any stage will cause the entire operational cycle to be interrupted. This explains why hangar reliability verification is more complex than that of a single piece of electromechanical equipment: it concerns not the reliability of an individual mechanism, but the system reliability resulting from the timed coordination of multiple mechanisms.

1.1.3 The hangar is a mechatronic system rather than a housing.

From the operational cycle described above, it can be inferred that the engineering nature of a hangar is that of a precision electromechanical system requiring long-term, stable operation in harsh outdoor environments. Its fundamental distinction from a conventional outdoor enclosure lies in the following:

There are moving parts: mechanisms such as doors, centering, lifting, and battery swapping all contain precision transmission components — including motors, gear reducers, limit switches, and lead screws—which are susceptible to failure modes such as wear, jamming, and missed steps.

Temperature control is required: lithium-ion battery charging is sensitive to operating temperature (typically $5°C-45°C$); in extremely cold environments, heating and thermal insulation are necessary, while in high-temperature environments, active cooling is required. Temperature-control accuracy directly affects battery life and charging safety.

Precision requirements: The centering and positioning accuracy is typically at the millimeter level; if the misalignment of the charging contact points is too large, it can cause poor contact, sparking, or even burnout.

Multiple concurrent devices: multiple subsystems — including charging, temperature control, communications, sensors, and flight control — operate simultaneously; therefore, power budgeting and electromagnetic compatibility must be designed in an integrated manner.

Requirements for remote operations and maintenance: deployment in remote locations such as field sites, vehicle roofs, and offshore platforms where personnel cannot be stationed permanently; these environments require capabilities for remote diagnostics, software upgrades, and self-healing from faults.

These characteristics dictate that the design of the hangar cannot simply adopt generic housing standards; instead, a dedicated modular technical framework must be established.

This article does not cite industry statistical data such as market size, growth rates, or shipment volumes: such data differ significantly in methodology and timeliness and have no inherent connection to the technical framework of this document. For assessments of industry trends, please refer to authoritative third-party reports or publicly

available policy documents.

1.2 Diversity of application scenarios

1.2.1 Scenario Spectrum

Based on the product forms and adaptation records for which HEISHA has already delivered products, the following eight major application scenarios can be identified. Each category is supported by corresponding product evidence rather than theoretical deduction.

Scene category	Typical Applications	Empirical product	Key environmental/task constraints
Extreme Environment Inspection	Polar scientific research, mining area monitoring, desert pipeline inspections, and border security and control	D90 (IP65, -40 °C to +65 °C, C4-M corrosion protection, accumulated snow ≥ 120 kg/㎡)	Extreme cold/extreme dust/high-salt mist composite environments make it difficult for personnel to remain stationed there long-term.
Coastal and Maritime Affairs	Coastal security, offshore platforms, and shipborne deployment	D90 C4-M corrosion protection; classification society certification references (image77~83.png)	Salt spray corrosion, vibration, humidity, and limited onboard space
Emergency Response and Mobility	Emergency communications, patrol and surveying, and temporary deployment	DCAP series, in-vehicle embedded ZIGLER (image 52 – 57)	Vehicle-mounted vibration, rapid deployment, limited size and weight, DC12V – DC24V power supply
Logistics and Transfer	Logistics terminal lockers, low-altitude cafeterias, and multimodal logistics	T-series (T20/T400/T60), V200 container vertical lift hangar, and D330	Exchange/replacement operation, high-frequency takeoff and landing, heavy

Scene category	Typical Applications	Empirical product	Key environmental/task constraints
	transfer services	vertical lift hangar	payload, container integration
Indoor and Warehousing	Indoor Warehouse Inspection	Owl indoor unit storage room (image 49–51)	Limited indoor space; no waterproofing required, but dust protection is needed; quiet operation
Downward-fixed-wing aircraft	Long-duration surveying and mapping, pipeline inspection	D330 is compatible with the Yuandu Lingjun ZT-25V; V200 is compatible with Ark 20.	Paddle control/airspeed tube treatment, increased wing span, and control of the vertical takeoff transition section
Tethering operations	Continuous monitoring, emergency lighting, and communication relay	Flaredynamic TETHER DRONE: Customized tethered hangar solutions	Tethered cable management, high-voltage power supply, cable-retraction commands, and prolonged continuous operation
Portability and Temporary Deployment	Rapid field deployment and emergency surveying	D007 wheeled garage-type vehicle, D90 field rapid hoisting and deployment	Lightweight design; handheld/trolley transport; rapid deployment; off-grid power supply

1.2.2 Figure 1-1 Application Scenario Spectrum

Mind map

root((Drone Hangar
Application Scenarios))

Extreme environments

Polar Scientific Expedition D90

Mine area monitoring D90

Desert Pipeline D90

Border Control D90

Coastal Maritime Affairs

Coastal Security

Shipborne deployment

offshore platform

Emergency Mobility

Emergency Communications DCAP

Inspection and Mapping: ZIGLER

Vehicle Modification: DCAP PRO

Logistics Transfer T-Series

Logistics Terminal T Series

Container Lift V200

D330 Hangar Lift

Indoor warehousing

Warehouse Inspection: Owl

Downward-fixed-wing aircraft

Yuan Du Ling Sun ZT-25V

Ark 20

Tethering operations

TETHER DRONE

Customized mooring hangar

Portable deployment

D007 Luggage Carry-on

D90 Rapid Hoisting

Figure 1-1 Spectrum of UAV hangar application scenarios (summarized based on the delivered product forms of HEISHA)

1.2.3 Analysis of Differences in Scenario Constraints

The table above reveals a key fact: requirements for hangars vary dramatically across different scenarios, and these differences span multiple technical dimensions. The following matrix further quantifies this variability:

Constraint dimension	Extreme environment (D90)	vehicle(DCAP)	Logistics (T Series)	Indoor (Owl)	Fishing line (customized)
working temperature	-40℃~+65℃	-20℃~+55℃	-20℃~+55℃	normal atmospheric temperature	-20℃~+55℃
levels of protection	IP65	IP54	IP54	IP24	IP54
Corrosion resistance rating	C4-M	Routine	Routine	not have	Routine
power supply mode	AC220V / Off-grid photovoltaic system	DC12V-DC24V	AC 220 V / three-phase	AC220V	High-voltage tethered power supply
Deployment method	Concrete / Mobile Shelter / Lifting	Roof rack/Integrated	Ground-mounted/Containerized	Indoor flooring	Ground fixation
Special movements	Heating and heat retention / anti-condensation	Seismic isolation / dynamic attitude compensation	Exchange/Battery Swap	Quiet operation	Line Collection/High-Voltage Management
communication mode	4G/5G/Satellite	4G/5G	Ethernet/4G	Ethernet/WiFi	Ethernet/4G
weight restrictions	500kg	≤100kg	no limit	no limit	no limit
Size restrictions	1550 × 1550 × 1740mm	1850 × 1050 × 356mm(DCAP PRO)	no limit	no limit	no limit

The core conclusion of this table is that no single standard product can simultaneously meet the requirements of all application scenarios. Each scenario imposes unique constraints in at least two or three dimensions; these constraints directly determine the structural configuration, transmission solution, electrical configuration, and control logic of the hangar. This is the fundamental reason why hangars must be customized.

1.3 Five Sources of Customization Requirements

Based on the product configurations, compatibility lists, and technical parameters available in the existing data, the sources of custom aircraft hangar requirements can be categorized into five dimensions. Each categorization is supported by empirical evidence.

1.3.1 Model Variations

HEISHA supports more than 50 compatible drone models across over 25 brands, spanning a wide range from the DJI MINI 3 (consumer-grade, <1 kg) to the M400/Ark 20 (industrial-grade,>20 kg). Different models exhibit significant differences in the following parameters:

Runway spacing and configuration: determine the stroke, clamping method, and positioning accuracy of the centering mechanism

Overall machine weight: ranging from <1 kg to>20 kg; this determines the driving torque and structural strength of the lifting mechanism.

Battery specifications: from 2S to 18S, with a voltage range spanning 7.4V−66.6V, which determines the voltage/current compatibility of the charging module

Charging interfaces: contact charging footprints, direct battery charging, and wireless charging transmitters; each interface has different mechanical alignment accuracy requirements.

Flight control protocols: DJI MSDK/PSDK, MAVLINK (PX4, ArduPilot, INAV), Fengyi flight control, and third-party packaged flight control; each protocol has a different method of integration and a different set of control commands.

1.3.2 Task differences

Different application scenarios impose entirely distinct functional and operational requirements on the hangar:

Inspection type: Requires only charging and involves the fewest functional operations (return to center + charging + opening/closing the lid).

Logistics category: Requires swap/swap-by-electricity operations, involving active modules such as three-axis swapping (ND04−ND06), lifting swapping (ND10−ND12), and three-axis battery swapping (ND01−ND03).

Agricultural category: may require a water addition unit (ND16−ND18)

Hydrogen-powered category: requires a three-axis refueling system (ND07−ND09)

Downward-fixed-wing configuration: requires a pitch control mechanism (ND19−ND21), corresponding to the API pulp_motor command (thus, it should be "pitch down")

and the centering module command codes 71/72

Tethered type: requires management of tethered cable deployment and retrieval, as well as a high-voltage power supply interface.

This means that even when the cabin and the centering mechanism are identical, different mission types can result in entirely different active modules.

1.3.3 environmental difference

The environmental conditions under which HEISHA products are applied span an extremely wide range:

Environmental parameter	Minimum value	maximum value	Empirical Evidence
working temperature	-40℃	+65℃	D90 Specifications Table
levels of protection	IP54	IP65	D80/D135 (IP54), D65 storage unit main body (IP55), energy storage cabinet (IP64), D90 (IP65)
Corrosion resistance rating	Conventional outdoor paint	C4-M	D90 Specifications Table
Snow load	—	≥120kg/㎡	D90 Specifications Table
classification of wind resistance	—	Typhoon of Level 12	Typhoon of Level 12
Dust-proof	Common	Fully enclosed multi-stage dust protection + PTFE open components	D90 Ultra-Particle Protection System

Environmental differences directly determine the selection of cabin materials, sealing processes, temperature control solutions, corrosion-resistant coatings, and fastener materials. The configuration of the same type of hangar may differ entirely between temperate cities and polar mining areas.

1.3.4 Differences in site and power supply

The deployment and power-supply methods for HEISHA products cover a variety of combinations:

Deployment options: ground-mounted concrete mounting (D80/D90), cabin integration (D90), roof-mounted luggage rack (DCAP series), suitcase-style mounting (DCAP PRO), container integration (V200), indoor floor mounting (Owl), rapid field lifting (D90), carry-on suitcase design (D007)

Power supply options: AC 220 V mains power, AC 110 V (for export models), three-phase power, vehicle-mounted DC 12 V－DC 24 V, off-grid photovoltaic energy storage systems, and diesel generator compatibility

Differences in the facility layout and power supply requirements determine the overall structural design of the hangar, the type of base, cable specifications, and the selection of power supply modules.

1.3.5 System interface differences

The interface protocols and communication methods supported by HEISHA include:

Control protocols: MQTT device model (14 topic categories), MODBUS RTU, MODBUS TCP

Communication interfaces: full-network compatibility with 4G/5G, Ethernet RJ45/POE, RS485, STARLINK satellite communications, private networks, and multi-redundant communication interface switching

Flight control platforms: DJI MSDK, DJI PSDK, MAVLINK open-source flight control (PX4, ArduPilot, INAV), Fengyi flight control, and third-party packaged flight control (customization available)

Software product line: HSC-MSDK-DJI, HSC-MSDK-MAV, HSC-PSDK-DJI, DNEST-APP-DJI, DNEST-APP-MAV, DNEST-WEB-DJI, DNEST-WEB-MAV, QRPL-M4E, QRPL-Mini, Q100 V2.0

Differences in system interfaces determine the method by which the aircraft hangar interfaces with the customer's existing systems. For integrators of existing cloud platforms and management systems, interface protocol compatibility is often the primary consideration when making a selection.

1.3.6 Information dimensions for customization requirements

Question 4 in the FAQ outlines nine major categories of considerations for customizing a HEISHA mining facility: basic specifications, structural transmission and deployment design, environmental adaptability requirements, intelligent components, power supply management, charging management, communications, UAV-assisted systems, and interfaces and documentation. These nine categories have been developed in Chapter 9 into a structured RFI (Request for Information) checklist; each item includes requirements, optional values, design decisions affected, and consequences of omission.

The very existence of nine major categories of considerations underscores the complexity of aircraft hangar customization: a complete set of customized requirements must cover at least dozens of parameter dimensions; the omission of any single dimension can lead to rework of the solution. This is also why information asymmetry is the primary pain point under traditional customization models (see Section 1.4 for

details).

1.4 Three Pain Points of the Traditional Customization Model

1.4.1 cycle length

Under the traditional customization model, each hangar project is designed from scratch and must undergo a complete design → prototype development → validation cycle. The cabin structure, transmission solution, and electrical layout for each project must be replanned, making it impossible to reuse previously validated drawings and BOMs.

Typically, across the entire process, the customization cycle ranges from 30 to 90 days, depending on the level of complexity.

1.4.2 High cost

The cost implications of non-standardized design are reflected at three levels:

Design cost: Each project requires the allocation of engineers for conceptual design, drafting, simulation, and review.

Material costs: Non-standard parts cannot be purchased in bulk, so their unit price is substantially higher than that of standard parts; the manufacturing cost of small-batch machined parts is also significantly higher than that of mass-produced parts.

Verification cost: Each redesign entails additional verification effort, including assembly and commissioning, functional testing, and environmental testing.

The impact of modularization on costs lies in predictability rather than in simple price reductions: customization efforts are concentrated on interface and dimensional adjustments; the reuse rate of standard components and validated structures increases; and quotes can be generated in advance based on the module inventory; meanwhile, the reuse of drawings and BOMs reduces the need for rework and trial production — two aspects that are typically the most difficult to estimate in the cost of customized projects.

1.4.3 Reliability is uncontrolled

The "Technical Challenges Overcome" list documents approximately 70 real-world engineering problems encountered in actual projects. These problems span all subsystems of the hangar; representative entries are listed below by category:

question type	Representative Issues (word-for-word)	Relevant engineering fields
Power Supply and Power	ACK150 voltage instability causes charging to fail; insufficient and unstable power in the deployment environment prevents normal operation; the power supply on the power-on board is insufficient; and the 12 V power supply within T3 is insufficient.	Power supply design, power budgeting, voltage stability
heat management	ACK temperature too high, resulting in failure to operate normally; D250 Raspberry Pi overheating; high-current switch LDO overheating; ACK800 prone to burnout	Heat dissipation design, thermal simulation, and component selection
Return to base and charging	DCAP exhibits a deviation in the coaxiality of the centering screw; D135 has a slight tilt in its centering push rod, resulting in poor contact; D250 has a contact issue with the charging electrode; M4E experiences frequent power cycling during charging.	Mechanical precision, assembly process, contact design
Transmission and Structure	D250 pusher motor loses a step; during drum operation, the upper cover scrapes against the inner side of the support leg; the bottom cover in the DCAP V3 version is too soft and prone to deformation; the D250 lift-to-top limit interferes structurally with the mechanism and fails to disengage.	Motor selection, structural stiffness, and limit-position design
Multi-device concurrency	When the DCAP remote controller and the drone are charged simultaneously, the entire system shuts down; when charging the DCAP V3 M4E, the device cannot be released from the centering position; if the remote controller and the M4E drone are charged simultaneously, the airport will go offline.	Power allocation, timing control, resource contention
Sensors and Communications	Temperature and humidity caused the device to burn out, resulting in D135 returning to center and charging, and 485 offline; the rainfall count value failed to reset to zero; D135 485 offline; the network RTK fails to connect automatically.	Sensor reliability, EMC, and communication stability
Materials and Sealing	Material rusting issue; D250 leakage; anemometer damaged during transport	Material selection, sealing process, packaging and transportation
Software and Control	HSC cloud entry application crashes; DJI RC Plus remote control fails to power on probabilistically; unable to determine whether the DJI remote control is powered on; DJI PILOT cannot start normally	Software stability, state machine design, and exception handling

The above classification is intended solely to illustrate the distribution of issues and does not correspond to the completed rectification checklist. Approximately 70 records themselves constitute direct evidence of accumulated engineering experience: each record corresponds to one field failure and one design iteration, and the lessons learned from their resolution have been fed back into the design of subsequent modules. The mechanistic analysis and key considerations for addressing typical issues are presented in sections 8.7 and 9.9.2.

The value of this checklist lies in the fact that it is a direct record of eight years of real-world project experience, rather than the result of theoretical deduction. Each question corresponds to a field failure, a rework, or a design iteration. It is the accumulation of these issues that drives engineering decisions regarding modular encapsulation: when the same problem recurs repeatedly across different projects, consolidating it into a validated standard module is more reliable than redesigning it

every time.

1.4.4 The Deep Root Causes of the Pain Points

The underlying root causes of the three pain points can be attributed to three "nots":

1. Information asymmetry: Customers do not know what requirements they need to specify (thereby overlooking critical constraints), while suppliers do not know the customers' actual usage scenarios (designing based on nominal parameters rather than actual operating conditions). The nine major categories of considerations in Question 4 of the FAQ constitute precisely the structured requirement-input tool designed to eliminate this asymmetry.

2. Knowledge does not become institutionalized: the lessons learned from each order remain confined to personal memory or unstructured documents, rather than being transformed into reusable modules, drawings, and BOMs.Approximately 70 "technical issues overcome" involve only problems without solutions——a typical manifestation of knowledge that has not been institutionalized.

3. Inconsistent interfaces: Each time a protocol and interface is redefined, the effort required for software adaptation increases linearly with the number of projects. HEISHA's unified MQTT object model and MODBUS register mapping were developed specifically to address this issue (see Chapter 7 for details).

1.5 The Solution to HEISHA and Its Ecological Niche

1.5.1 Solution: Transform "customization" into "modular composition"

The solution for HEISHA involves abstracting all mechanical operations in the hangar into three categories (door operations, mechanical operations, and active operations), with each category further modularized and encapsulated according to "transmission method × size range." To date, a matrix of three-operation modules comprising 69 codes has been established:

Door actuator MD01−MD24:8 drive configurations × 3 size ranges, totaling 24 codes

Mobile JD01−JD24:8 transmission modes × 3 size ranges, totaling 24 codes

Active ND01–ND21:7 transmission modes × 3 size ranges, totaling 21 codes

In conjunction with a six-tier technical architecture (L0 – L5), a unified interface protocol (a single API shared by all hangars and a single API shared by all UAV models), and a structured requirements input tool (nine major categories of RFI), customized projects have shifted from "redesigning every single order" to "selecting modules + combining them + parameterized adjustments."

Detailed technical solutions for each layer are presented in the subsequent chapters: -L0: Cabin structure and environmental adaptability: see Chapter 5; -L1: Three-motion module of the transmission and actuation layer: see Chapter 3; -L2: Electrical and energy layer: see Chapter 4; -L3: Control and perception layer: see Chapter 6; -L4: Interfaces and development protocols: see Chapter 7; -L5: Delivery and operations-maintenance methodology: see Chapter 9.

1.5.2 Niche: We do not provide comprehensive solutions; we focus solely on the hangar platform.

FAQ Q2 provides a clear answer regarding the positioning of HEISHA:

Q: Can Heisha provide products comparable to DJI Airport? A: No. DJI DOCK offers a comprehensive solution, whereas Heisha provides only hangar infrastructure and related customization. In other words, our integration customers can benchmark their solutions against DJI Airport.

This response clearly defines HEISHA's B2B2B niche:

Avoid competing with integrators in the end-user market: Heisha's customers are solution providers (integrators), not end users. After integrating Heisha's hangar platform, integrators combine it with their own drones, software, and services to deliver a comprehensive solution for end customers.

Building the foundation for customer capabilities: Heisha provides an aircraft hangar hardware platform and underlying interfaces; integrators then build differentiated competitive advantages on this foundation. This means that Heisha's success depends on the success of its integrators—interests are aligned rather than competitors are rivals.

The value of the three product boundaries: The "product boundaries" clearly define three areas in which the company will "not do" —it will not provide complete solutions, will not manufacture drones, and will not develop cloud-based business software. These three "no-do" commitments are precisely the prerequisite that allows integrators to

integrate services with confidence: suppliers will not extend downstream into the customer's profit margin.

1.5.3 Category scalability

The answer to Question 3 in the FAQ highlights the potential for category expansion:

Q: Can Heisha provide custom charging stations for robotic dogs? A: Yes. Heisha specializes in building facilities for robots; we can provide wired and wireless charging stations customized for robotic dogs, as well as charging stations customized for unmanned tractors and unmanned boat drones.

The key implication of the positioning "building houses for robots" is that the modular capabilities accumulated by HEISHA—covering structure, power transmission, electrical systems, temperature control, and interfaces—are not tied to any particular drone model; instead, they can be transferred to other forms of unmanned systems. The requirements at the aircraft-housing level for robotic dogs, unmanned tractors, and unmanned aircraft boats—storage, protection, charging, and automated entry and exit—are highly similar to those for drones; the primary differences lie in size, weight, and charging interfaces, which are precisely the variables that a modular architecture excels at handling.

1.5.4 The Meaning of One-Stop Service

The meaning of "specialized customization and one-stop service" can be understood from the perspective of a six-tier technical architecture:

top class	The abilities provided by HEISHA	An integrator does not need to seek out additional suppliers.
L0 Cabin Structure	Extreme Cold / Extreme Dust / Corrosion Resistance / Rain and Snow Loads / In-Vehicle Use, and other environmental packages	Sheet metal fabrication plants, coating plants, and sealing component suppliers
L1 Drive Execution	69 coded three-motion modules; the drawing BOM has been finalized.	Transmission design companies, motor suppliers, and gear reducer suppliers
L2 Electrical Energy	ACK charging module series, energy storage cabinets, power consumption budget	Power supply design companies and charging pile suppliers
L3 Control Perception	Temperature control / Vision / Fire protection / Alarm / T100 local control	Thermostatic equipment suppliers, visual solution providers, and fire protection equipment suppliers
L4 Interface Protocol	MQTT device model, MODBUS mapping, hardware control commands	Protocol development team, middleware provider

top class	The abilities provided by HEISHA	An integrator does not need to seek out additional suppliers.
L5 Delivery and Operations	RFI checklist, product selection decision tree, and milestone workflow	Project Management Consulting and Test Verification Services

The core value of one-stop services lies in the fact that integrators do not need to piece together the capabilities of multiple suppliers, thereby reducing system integration risks and communication costs.

1.5.5 Verifiable accumulation

The following quantifiable facts can directly verify the depth of Heisha's engineering experience:

metric	numeric value	data sources
entire period of actual operation	8 years	an account in one's own words
Total number of patents	36 items (invention: 18; utility model: 16; design: 2)	Itemized Statistics of the Patent List
Patent Maintenance	18 items (Invention 2, Utility Model 15, Design 1)	ditto
Pending substantive examination of the invention patent	5 items	ditto
Drone Compatibility Record	44 rows, covering over 25 brands	Compatibility List
Three-Motion Module Coding	69 (MD24 + JD24 + ND21)	Module Matrix Table
Product form	12+ types	Product Details Section
API version iteration	Approximately 30 versions (2025-05-01 to 2026-06-22)	API Documentation Version History
Product Documentation Version History	27 items (May 25,2025 – October 22,2026)	Version Update Chapters
Engineering Issue Record	Approximately 70 items	List of "Technical Challenges to Be Overcome"
Source Code Package Product Line	10 units (HSC series + DNEST series + QRPL series + Q100)	Software Product Catalog

Product documentation classifies self-declared capabilities into six major categories; based on verifiable criteria, this document groups them into five categories: modular structure and transmission, drone charging and auxiliary functions, performance and intelligent enhancement customization, complete development interface protocols, and provision of a simplified source code.

Existing documentation describes the delivery scale qualitatively as "a vast quantity of complete aircraft and components," without providing the number of deliveries, the customers, or the project locations. This article does not provide quantitative supplementation on this matter; the supplier's delivery scale is a matter for due diligence in the business context, and it is recommended that it be verified through a project checklist or third-party certification prior to entering into cooperation.

1.6 Structure and Reading Path of This Article

1.6.1 Overview of the Six-Layer Technical Architecture

This book adopts a six-layer technical architecture as its organizational framework; the layers are defined as follows:

top class	name	core content	Corresponding Chapter
L0	Cabin structure	Material selection, sealing and protection, environmental adaptability, and deployment methods	Chapter 5
L1	Transmission execution	Three-act module architecture (door actuation / mechanical actuation / active actuation), coding rules, and maturity	Chapter 3
L2	Electrical Energy	Charging module, energy storage cabinet, power consumption budget, power supply management	Chapter 4
L3	Perceptual Control	Temperature control, vision, fire protection, alarm, T100 local control, software product line	Chapter 6
L4	Interface Protocol	MQTT device model, MODBUS mapping, hardware control commands, event architecture	Chapter 7
L5	Handover and Operations Maintenance	RFI checklist, selection decision tree, milestones, risk mitigation, testing and validation	Chapters 8 and 9

1.6.2 Table of Contents and Notes

chapters and sections	title	One-sentence explanation
Chapter 1	Industry Context and Customization Challenges	Discussion on the necessity, challenges, and solutions to the customization of hangars (this chapter)
Chapter 2	Overall Technical Framework	Six-tier architecture definition, three principles of modularization, coding rules, and maturity matrix
Chapter 3	L1 Drive Execution Layer	Complete Coding, Parameters, and Selection Guidelines for the Three-Motion Module System
Chapter 4	L2 Electrical and Energy Layer	ACK Charging Module Series, Energy Storage Cabinets, and Power Consumption Budgeting Methods
Chapter 5	L0 Cabin Structure	Environmental adaptability design (extreme cold/extreme dust/corrosion resistance/rain/snow/vehicle-mounted)
Chapter 6	L3: Control Layer of the Perceptual Layer	Intelligent control, software product line, compatibility design
Chapter 7	Interfaces and Development Protocols	Comprehensive Guide to the MQTT/MODBUS Protocols, Register Mapping, and Event Architecture
Chapter 8	Reliability Verification and Testing System	Testing methods, verification criteria, and certification status
Chapter 9	Customized Delivery Methodology	RFI checklist, selection decision tree, milestone process, risk mitigation
Chapter 10	Application Forms and Case Studies	12+ product formats, patent portfolio, and demonstration of technical capabilities
Chapter 11	Technological Evolution Path	Evolutionary direction, capability gaps, and improvement recommendations based on evidence-based inference

1.6.3 Reading pathways for three types of readers

This article is intended for structural/electrical engineers working for integrators/developers and clients. The following recommended reading path is provided:

Path A: Integrator/Developer (focus on system integration and delivery processes) → Chapter 2 (Architecture and Coding Rules) → Chapter 7 (Interface Protocols, Key Focus) → Chapter 6 (Intelligence and Software Product Lines) → Chapter 9 (Delivery Processes) → Chapter 11 (Evolution Roadmap and Capability Boundaries)

Path B: Structural Engineer (focus on mechanical design and environmental adaptability) → Chapter 2 (Architecture Overview) → Chapter 3 (Three-Motion Module, Key Section) → Chapter 5 (Environmental Adaptability) → Chapter 9 (RFI Checklist) → Chapter 8 (Reliability Verification)

Path C: Electrical Engineer (focus on power supply, charging, and protocol interfacing)> Chapter 2 (Architecture Overview) → Chapter 4 (Electrical Energy, Key Focus) → Chapter 7 (Register Mapping) → Chapter 6 (Control Perception) → Chapter 8 (Testing and Verification)

1.6.4 Figure 1-2: Correspondence between chapters and the six-layer architecture

graph LR

Subgraph: Six-Layer Architecture

L0 [L0 Cabin Structure]

L1 [L1 Drive Actuation]

L2 [L2 Electrical Energy]

L3 [L3 Control Perception]

L4 [L4 Interface Protocol]

L5 [L5 Delivery and Operations]

end

subgraph section

CH3 [Chapter 3: Three-Motion Module]

CH4 [Chapter 4: Electrical Energy]

CH5 [Chapter 5: Environmental Adaptability]

CH6 [Chapter 6: Intelligent Control]

CH7 [Chapter 7: Interface Protocols]

CH8 [Chapter 8: Reliability Verification]

CH9 [Chapter 9: Delivery Methodology]

end

L0 --> CH5

L1 --> CH3

L2 --> CH4

L3 --> CH6

L4 --> CH7

L5 --> CH8

L5 --> CH9

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Figure 1-2: Correspondence between chapters and the six-layer architecture

1.6.5 Data Boundary Declaration

This article is based on the materials provided by Heisha:

1. "HEISHA Product Introduction" (October 22,2026 edition; includes product specifications, compatibility list, patents, certifications, FAQ, and more)

2. "HEISHA Enters the Cloud API" (June 22,2026 edition, including MQTT device

models, MODBUS mappings, version history, etc.)

3. "HEISHA Object Model and Register Mapping Table" v1.0 (2026.9.13)

This document does not include estimated values for projects for which no measured or commercial data support has yet been obtained; these are summarized by category in Appendix E and primarily include:

External data on industry market size, growth rate, shipment volume, and other metrics

Production capacity (capacity, site, equipment, personnel, delivery cycle)

Third-party test reports for IP protection ratings and laboratory reports on environmental adaptability

Customer Case Study (Customer Name, Project Location, Quantity Delivered, Measured Operational Data)

Solutions to approximately 70 engineering issues

Quantitative definition of the "large/medium/small" size ranges for the module

Inconsistencies in certain product parameters (see Chapter 11, Section 11.6 for details)

A complete list of data gaps and recommendations for improvement can be found in Chapter 11.

Charpter 2 Overall Technical Framework

Chapter 1 addresses the question, "Why must a hangar be custom-built?" This chapter answers the question, "What technical framework does HEISHA use to make customization predictable?" The framework consists of three components: a six-layer technical architecture (which stratifies and repositions all technical elements of a hangar), three modular principles (engineering conventions that enable modular combinations), and a coding and maturity system (a means of expressing combinations that is describable, quoteable, and verifiable).

2.1 Overview of the Six-Layer Technical Architecture

2.1.1 Why use layering?

The technical components of a UAV hangar span six engineering disciplines: structural, mechanical, electrical, electronic, software, and communications. If these are laid out side by side in a single checklist — as is the case in the drafting of original framework documents — readers cannot determine "which parts will be affected by a change in one area"; integrators cannot assess the boundaries of their own modifications; and HEISHA cannot internalize its experience into reusable assets.

The purpose of layering is to isolate technical elements that differ in their change frequency, responsible entities, and verification methods: once the architecture layer has been finalized, it rarely undergoes changes, whereas the protocol layer continues to iterate in response to evolving requirements; the architecture layer is managed by black-sand structural engineers, while the interface layer requires joint debugging with the customer's cloud platform. After layering is implemented, customization becomes "making choices or extensions in certain layers while leaving the remaining layers unchanged."

2.1.2 Six-Level Definition

layer	name	duty	Content carried	Corresponding Chapter
L5	Delivery and Operations Layer	Translate the technical framework into an executable project workflow	Requirements Input List (RFI), selection decision-making, project milestones, deliverers, after-sales service and operations & maintenance	Chapters 9 and 10
L4	Interface Protocol Layer	A unified protocol for exposing all hardware capabilities to external parties	MQTT device model, 14 topic categories, Modbus register mapping, hardware control commands, event architecture, software product line	Chapter 7, Chapter 6, Section 6.9
L3	Control the perception layer	Perceive the environment, execute decisions, and operate with local autonomy	T100: local control, temperature control strategy, visual capabilities, fire safety management, drone compatibility and adaptation, alarms and status awareness	Chapter 6
L2	Electrical Energy Layer	Power input, distribution, conversion, and storage	Power supply solution, ACK charging module, energy storage cabinet, UPS, power consumption budget, electrical safety	Chapter 4
L1	Transmission Execution Layer	Modular encapsulation of all mechanical movements	Mechanical MD01 – MD24, motorized JD01 – JD24, and active ND01 – ND21: coordinated sequencing and state machine for the three-motion linkage	Chapter 3
L0	Cabin structural layer	Physical boundaries and environmental barriers	Cabin structure, thermal insulation, sealing, protection rating, corrosion resistance, structural load, and vehicle adaptability	Chapter 5

2.1.3 Interlayer relationships and dependency direction

The dependencies between the six layers constitute a bottom-up containment relationship and a top-down invocation relationship:

Load-bearing direction (lower layer supports the upper layer): the L0 cabin provides the mounting reference and sealing boundary for the L1 drive; the L1 drive provides the mechanical precision required for the alignment of the L2 charging contacts; L2 supplies power to all electronic equipment in L3; the control outputs of L3 actuate the actuators in L1 and L2; L4 abstracts the capabilities of L1−L3 into a protocol; and L5 organizes the above layers into a project.

Call direction (upward and downward): The cloud platform issues commands via L4; L3 decodes them and coordinates the execution by L1/L2; L3's local autonomy (T100) directly drives L1/L2 when the network is disconnected, bypassing L4.

This structure gives rise to two important engineering properties:

1. Changes within a layer do not propagate beyond the layer. Switching the door operation mode (L1) does not require any changes to the protocol (L4)——because the protocol abstracts the "hatch" semantics through cover_open/cover_close, regardless of whether the underlying mechanism is a roller shutter or a rolling shutter. This is precisely the structural foundation that enables "all hangars to share a single API."

2. Reliability responsibility can be assigned to specific levels. A field fault can be assigned to a particular level (power supply issues at L2, medium-level accuracy at L1, condensation at L0, and false status alarms at L3), thereby providing clear accountability for the issue list in Chapter 8 and the risk list in Chapter 9.

Figure 2-1 Overview of the six-layer technical architecture:

graph TB

subgraph L5 [L5 Delivery and Operations Layer]

A1 [Requirement Input RFI] --> A2 [Product Selection Decision] --> A3 [Milestones and Deliverables] --> A4 [Post-Sales Operations and Maintenance]

end

subgraph L4 [L4 Interface Protocol Layer]

B1 [MQTT physical model, 14 categories of Topics] --> B2 [Modbus register mapping]

B2--> B3 [Hardware control instructions / event architecture]

B3--> B4[HSC / DNEST / Visual SDK]

end

subgraph L3 [L3 controls the perception layer]

C1[T100 Local Control − Resume Operation After Network Disconnection] --> C2[Temperature Control / Vision / Fire Protection]

C2--> C3 [Drone compatibility and adaptation]

C3--> C4 [Alarm and Full Awareness Reporting]

end

subgraph L2 [L2 Electrical Energy Layer]

D1 [Power Supply Solution: Grid Power / On-board Power / Photovoltaic Power / Energy Storage] --> D2 [ACK Charging Module: 2S−18S]

D2--> D3 [UPS and Power Redundancy]

D3--> D4 [Power Consumption Budget and Electrical Safety]

end

subgraph L1 [L1 Drive Execution Layer]

E1 [Door actuation MD01−MD24] --> E2 [Motor actuation JD01−JD24]

E2--> E3 [Active ND01−ND21]

E3--> E4 [Three-Act 联动 Sequence and State Machine]

end

subgraph L0 [L0 Hull Structural Layer]

F1 [Cabin Structure and Materials] --> F2 [Sealing and Protection Class]

F2--> F3 [Corrosion Protection and Structural Loads]

F3--> F4 [In-vehicle and Mobile Adaptability]

end

L5-Organization. -> L4

L4-Abstract exposure. -> L3

L3-Control drive. -> L2

L2-Power support. -> L1

L1-Mechanical load-bearing. -> L0

2.2 The Three Principles of Modularization

The six-tier architecture addresses the issue of "putting elements back into their proper places," while the three principles of modularity address the question of "how a module can be considered composable." These three principles are engineering conventions distilled from eight years of practice at Heisha; they also serve as criteria for determining whether a custom requirement "can be met using existing modules."

2.2.1 Principle 1: Unified interfaces

Statement: Each module exposes only a semantic interface to its callers and does not expose implementation details.

Empirical evidence (protocol side): Regardless of whether the hatch uses a roller mechanism (MD10–MD12) or a vertical roller shutter (MD22–MD24), the protocol layer exposes the same set of semantics—cover_open / cover_close commands and cover_state status (0: closed / 1: open / 2: half-open / 3: abnormal / 9: unknown). Regardless of the size class, the centering mechanism exposes the same set of semantics as the rotate_motor_position class and the centering rod state machine (0x00 UNKNOWN / 0x01 UNLOCKED / 0x02 LOCKED / 0x03 LOCKING_STEP1 / 0x04 LOCKING_STEP2 / 0x05 UNLOCKING / 0x06 FAULT).

Empirical evidence (mechanical side): The charging module couples with the centering mechanism via a unified electrode interface (gold-plated electrode); the centering accuracy determines the reliability of contact engagement. Consequently, "charging compatibility" is fundamentally a matter of "mechanical compatibility of the centering interface," rather than an electrical issue. This coupling relationship is discussed in Chapter 4, Section 4.2.1.

Engineering implications: Unified interfaces enable (a) cloud-based software to eliminate the need to write drivers for each type of device; (b) modules to be replaced without affecting the upper layers; and (c) faults to be localized semantically ("cover an exception" rather than "a particular motor has failed").

2.2.2 Principle 2: Size Ranges

Description: For the same transmission method, the dimensions are discretized into a finite number of gear ratios rather than being treated as a continuously variable parameter.

Evidence: The second dimension of the three-motion coding table is the size range—each transmission mode is fixedly divided into three levels: large, medium, and small. Door motion: 8 modes × 3 levels = 24 codes; power transmission: 8 modes × 3 levels = 24 codes; active motion: 7 modes × 3 levels = 21 codes; totaling 69 codes.

Engineering implication: Dimensional tiering compresses an infinitely continuous design space into a finite set of discrete options. For HEISHA, this means that each tier requires only one set of drawings and a BOM to be finalized; for integrators, it means that component selection is "tier selection" rather than "parameter definition," allowing quotes and delivery schedules to be finalized in advance.

The criterion for classifying dimensions primarily focuses on compatibility with the drone's takeoff and landing envelope (the larger of the landing gear envelope or the blade-outspan diameter is used); the net opening dimensions of the fuselage are used for verification, with three categories—large, medium, and small (the quantified ranges are provided in 2.3.3). This criterion can be directly derived from the publicly disclosed parameters of the aircraft model; based on this, integrators can determine which class the model belongs to without the need for individual-case verification during the pre-sales stage.

2.2.3 Principle 3: Maturity Leveling

Statement: Modules must specify their degree of hardening to enable the management of customization expectations.

Empirical evidence (there are clear differences in the formulation of the three-dimensional maturity framework):

Module Family	Related phrasing	Inferred maturity
Door actuator MD01 – MD24	"The drawings and BOM have been finalized; the related motors, drives, gearboxes, limit switches, and other components have also been finalized." "We have essentially achieved comprehensive coverage of customized requirements for various hangars."	Cured
Mobile JD01–JD24	"The drawings and BOM have already been finalized," and "they basically cover a wide range of customization scenarios."	Cured

Module Family	Related phrasing	Inferred maturity
Active ND01–ND21	"Some of the approaches have already been modularized and encapsulated. As the range of hangar scenarios continues to expand, so will the number of functional operations; we will further standardize more drive modules."	Partial curing

Project implication: Maturity directly determines cycle time and risk. Selecting a hardened module equates to "receiving the deliverable," while selecting an unhardened module equates to "research and development." Explicitly highlighting this distinction demonstrates integrity toward the integrator and protects HEISHA's own delivery expectations.

Maturity is managed by coding level: for the mechanical and electromechanical families, the drawings, BOMs,motors, drives, reducers, and limit switches have all been finalized; all codes are assigned once the design has been finalized. The electromechanical family is subdivided by functional action; its maturity advances incrementally with each code as delivery validation is completed; the determination criteria are provided in Section 2.4.2. When requesting a quotation, the current level of the selected code should be requested directly.

2.2.4 The Relationship Between the Three Principles and the Boundary of Customization

The three principles together define the three forms of "customization":

Customized form	Triggering Principles	Typical workload
Module Selection	Principle 2 (Module Selection) + Principle 3 (Selection of Already-Customized Modules)	Minimum: Select equipment by consulting the table
Module Combination	Principle 1 (Interface Unification Ensures Composability)	Middle: Combined Verification and Joint Debugging
Module Extension	Principle 3 (Apply to unconsolidated modules)	High: Enter the R&D process

The vast majority of custom projects fall into the first two forms. This is the precise meaning of the proposition "transforming customization into a modular combination": not every requirement can be handled without development; rather, requirements that can be handled without development should be identified quickly.

2.3 Coding System and Naming Conventions

2.3.1 Encoding structure

Three-motion encoding adopts a "letter segment + two-digit sequence number" structure:

Letter block	meaning	Sequence Number Range	Number of codes
MD	Door actuation (hull door actuation method)	MD01 – MD24	24
JD	Mobility (drone mobility mechanism)	JD01 – JD24	24
ND	Actuation (drone functional actuation mechanism)	ND01 – ND21	21

The correspondence between the sequence number and the two-dimensional matrix follows row-major order: taking door operation as an example, MD01−MD03 represent the first transmission mode (dual-opening smooth operation) with large, medium, and small three-speed settings; MD04 − MD06 represent the second mode (single-opening smooth operation); and so on, with MD22−MD24 representing the eighth mode (vertical roller shutter). Thus, sequence number = (transmission-mode sequence number − 1) × 3 + size-range sequence number.

The above sequence arrangement rules have been derived from existing encoding tables and may serve as a reference for expansion: for a given transmission method, the three size grades shall be assigned consecutive numbers; transmission methods shall be assigned sequentially by row; newly added methods shall be appended within the corresponding letter segment; no gaps shall be created, and no decommissioned codes shall be reclaimed.

2.3.2 Transmission Method Inventory

Door operation (8 types): double-opening smooth, single-opening smooth, double-opening rotary, roller, single-opening rotary, lifting rotary, lifting smooth, vertical roller shutter

Mechanical functions (8 types): centering, offset centering, translation, elevation adjustment, horizontal rotation, vertical magazine, magazine rotation, gravity centering

Active functions (7 types): three-axis battery swapping, three-axis unit replacement, three-axis hydrogen refueling, lifting-based unit replacement, robotic-arm battery swapping, water-filling mechanism, and rudder-control mechanism

Active coding has mixed four naming dimensions within the source data: number of motion axes (three-axis battery swapping, three-axis equipment swapping, three-axis hydrogen refueling); mode of motion (lifting for equipment swapping); mechanism type (robotic arm for battery swapping); and functional action (water-filling mechanism, rudder-retraction mechanism). This paper retains the original codes and original names as the unique identifiers and provides a unified interpretation at their first occurrence (mode

of motion/mechanism type + functional action), thereby preserving the traceability of historical project documentation.

The heading of the first table in the dynamic coding table appears as "function" in the source material; this is synonymous with the definition of "dynamic" in the main text, and this article uniformly uses the term "dynamic."

2.3.3 Notch Definitions and Recommendations for Size Classes

The size class is primarily determined by its compatibility with the drone's takeoff and landing envelope, and is divided into three classes:

Small category: fuselage external dimensions ≤ 500 mm and rotor blade span diameter ≤ 600 mm; applicable to light and small multirotors (Mavic 3E/T and 2S−4S class models);

Mid-range: landing gear span 500−900 mm or rotor blade span 600−1100 mm, corresponding to industry aircraft in the 4−15 kg class (Matrice 4E/T, M30, Matrice 350 RTK);

Major category: fuselage external dimensions ≥ 900 mm or rotor blade span ≥ 1,100 mm; applicable to heavy-load aircraft weighing 15 kg or more and fixed-wing aircraft with vertical takeoff capability (Matrice 400, Fengyi Ark 20, and larger aircraft models).

For models positioned at the boundary between gear positions, the gear position shall be determined based on whether the net opening dimensions of the cabin and the centering travel are sufficient to provide coverage; HEISHA shall verify this against the module catalog before finalizing the gear position. The criterion shall be the approved operational range specified in the engineering design; the actual coverage shall be subject to the module catalog.

It is recommended that the footprint suitable for the takeoff and landing of the unmanned aircraft—defined as the outer dimensions of the landing gear or the diameter when the blades are fully deployed, whichever is greater — be used as the primary criterion for gear-stage classification, supplemented by the size of the cabin opening as a verification criterion; the numerical ranges for each gear stage should also be specified. Rationale:

1. The primary function of a hangar is to accommodate specific types of unmanned aerial vehicles; the aircraft type is the primary input for requirements (see Chapter 9, RFI,

Category 1: "Basic Specifications");

2. Existing product specifications may serve as calibration data for tiered anchor points: the D80 is compatible with the Mavic 3E/T and Matrice 4E/T; the D135 is compatible with the Matrice 350 RTK; the D200 is compatible with the Matrice 400 and Fengyi Ark 20; and the D250 is compatible with Ark 20—there is a clear correspondence between the model sizes, from smallest to largest, and the corresponding product dimensions (see Chapter 10, Section 10.2, the side-by-side comparison table for details);

3. The takeoff/landing footprint is publicly available data provided by drone manufacturers; integrators can query this information independently and compare it against the specified categories, thereby enabling "independent model selection."

Before the tier definitions are announced, the integrator's selection process can only proceed as follows: provide a model → HEISHA confirms the tier. This introduces one manual interaction during the pre-sales stage.

2.3.4 Recommended encoding extension specifications

The original encoding scheme does not include version identifiers or extension procedures; it is recommended that these be added:

Standardized Item	Recommended content
New transmission method	Add a line within the corresponding character range, and the sequence number shall be incremented accordingly (for example, the 9th method occupies MD25–MD27).
New size range	If the fourth level is introduced (e.g., "extra-large"), it is recommended that an alphanumeric suffix (e.g., MD01-XL) be used instead of disrupting the existing three-level structure.
Version Identifier	Append a version suffix after coding (e.g., MD01-R2); upgrade the version when significant changes occur in the drawings or BOM.
Maturity Indicator	In the encoding table, mark ● / ◐ / ○ in an independent column (see 2.4); these do not enter the encoding string.
Retirement Mark	The coding designation for discontinued supplies indicates that they have been decommissioned but are not recovered or reused, ensuring traceability of historical project documentation.

2.4 Module Maturity Matrix

2.4.1 Recommended Level 3 labeling

A three-level maturity labeling system is adopted:

characteristic	name	definition	Meaning of customization
●	Cured	The drawings, BOM, motor, drive, reducer, and limit switches have all been finalized and validated across	Can be selected directly; cycle and cost can be provided as a

characteristic	name	definition	Meaning of customization
		multiple projects.	preliminary quotation.
◐	Parametrically adjustable	The main structure and core components have been finalized; dimensions, stroke, materials, and other parameters must be adjusted according to the project-specific parameters.	Select + parameter adjustment; medium cycle
○	Redesign required	Only conceptual or case-based experience exists; no finalized drawings or BOM have been developed.	Once the R&D process has been initiated, the cycle and associated risks must be assessed on a case-by-case basis.

2.4.2 Current inferable matrix states

Maturity is identified by code; the determination rules are as follows: if there are two or more delivery records for the same code within the past 24 months and no structural changes have occurred, the item is considered "cured" (●); if the main structure has been finalized, but the dimensions, travel range, or materials need to be adjusted according to the project, the item is considered "parameterizable adjustment" (◐); if there is only anecdotal experience or if drawings and BOMs need to be redrafted, the item is considered "requires redesign" (○). The current matrix status is as follows:

Module Family	Encoding range	Infer maturity	Basis for inference (relevant wording)
Door movement	MD01 – MD24 (all 24 codes)	● Cured	"The drawings and BOM have been finalized"; "the motor, drive, reducer, limit switches, and other components have all been finalized"; "the solution essentially provides comprehensive coverage for the customization needs of various hangars."
motor-driven	JD01 – JD24 (all 24 sizes)	● Cured	"The drawings and BOM have already been finalized," and "they basically cover a wide range of customization scenarios."
active	ND01 – ND21 (21 codes; the status of each code is unknown)	◐/○ mixing	"Some approaches have already been modularized and encapsulated"; "We will standardize more transmission modules."

The dynamic category represents the segment with the highest level of uncertainty during model selection. Taking a logistics scenario as an example, for "three-axis battery swapping" (ND04–ND06) and "robotic arm battery swapping" (ND13–ND15), if they are at ◐ level, the delivery pathway is "combination + parameter adjustment"; if they are at ○ level, they enter the R&D process, resulting in a difference in cycle time by an order of magnitude. When requesting a quote, the supplier should be asked to specify the level and delivery pathway of the selected code.

2.4.3 The Value of Maturity Indicators for Integrators

1. Pre-sales expectation management: Integrators can determine during the inquiry stage whether the selected configuration includes ○ -level modules, thereby avoiding commercial disputes arising later due to the R&D cycle.

2. Risk pricing: ○ Level modules shall be priced separately, with design verification milestones to be specified; ● Level modules may be quoted at the standard product price.

3. Acceptance basis: ● Acceptance of Level X modules may reference their historical validation records; ○ Level Y modules must undergo complete validation in accordance with the new project (see Chapter 8, Section 8.8).

2.4.4 Recommendations for the annotation of compositional existence

The three encoding tables form full-grid matrices ($8 \times 3 / 8 \times 3 / 7 \times 3$); however, not every combination of "transmission method × size class" is feasible in engineering practice — small-size compartments generally lack the internal space required to accommodate a multi-axis battery-swapping mechanism. Combinations that are practically non-existent or unreasonable are explicitly marked as N/A rather than left blank, so that readers do not confuse "not applicable" with "not provided."

2.5 Custom Boundary Declaration

Clear boundaries are a prerequisite for the B2B2B model. This section quotes verbatim the three product boundaries and supplements them with a list of customizable and non-customizable options derived from existing literature.

2.5.1 Product boundaries (word-for-word)

Heisha does not provide a comprehensive solution; instead, it focuses solely on the hangar platform itself and offers hangar infrastructure support to solution providers.

Heisha does not engage in the development or manufacturing of drones and robots; instead, it focuses solely on developing the hardware and software that assist drones in accessing their hangars.

Heisha does not develop cloud-based business software for complex flight missions,

outcome analysis, or AI processing; it merely provides the necessary API interfaces and basic task processing services.

These three boundaries have the following practical implications for integrators: HEISHA will not extend downstream to become a competitor to integrators; integrators can confidently build their cloud platforms, industry-specific algorithms, and task systems on HEISHA's interfaces (L4), eliminating the structural risk of being "eaten up by the supplier at the upper layer." The FAQ statement, "Our integrator customers can benchmark against DJI Airport," directly reflects this ecosystem positioning.

2.5.2 Customizable Items List (Evidence-Based)

class	Customizable content	data source
configuration	Ground-mounted, cabin integration, vehicle-mounted, rapid field lifting, roof rack, suitcase-style, containerized, indoor use, and carry-on suitcase design	Description of deployment methods for each product
Transmission assembly	Door actuation mode 8, mobile mode 8, active mode 7, and their dimensional ranges	Three-Action Coding Table
Environment Package	Extreme cold (-40 ° C), extreme dust protection (IP65 full sealing), corrosion resistance (C4-M), explosion-proof version, higher IP rating (IP65), and custom salt spray protection	D90 / D65 / D80 parameters
Power Supply Plan	Municipal power AC220V / AC100 – 240V / three-phase; vehicle-mounted DC12V/DC24V; off-grid photovoltaic energy storage; diesel compatibility	Power supply and energy storage cabinets for each product
Communication Solution	4G/5G, Ethernet POE, RS485, optional satellite communications, STARLINK, private networks, multi-redundant failover	Product Parameters and FAQ – Category 7
Intelligent Configuration	Number of cameras and camera angles; six essential components / simplified configuration of weather sensors; audio-visual alarms; status indicators; fire protection equipment; edge computing servers	FAQ: Category 4 and D90 Extended Configuration
surface	Colors, logo printing, warning signs	D80/DCAP Parameters
Software Delivery	HSC / DNEST source code, Visual SDK AAR, scheduling platform (WEB + APP)	Source Code Package Product Catalog

2.5.3 Items that cannot be customized or require third-party coordination

project	Boundary Description	data source
Drones-side retrofitting	HEISHA enables wireless charging on the aircraft side (with the transmitter positioned beneath the centering plate), but it cannot facilitate modifications to the UAV side for five reasons: battery architecture, payload configuration, obstacle-avoidance camera, coil integration, and others.	FAQ Question 1
Cloud-based business software	Complex flight missions, result analysis, and AI processing are not within the scope of HEISHA; only APIs and simple task processing are provided.	Product Boundary Clause 3
Communication module	The communication method module is provided by the customer, while	D90 System Topology

project	Boundary Description	data source
supply	Heisha is responsible for its integration.	Description
Flight Control Depth Function	HSC-DJI Basic Edition analysis: 42 out of 312 items covered (coverage: 13.5%); the remaining features require customers to extend or customize independently.	Basic Definition

2.5.4 A Qualitative Framework for Modification Effect Factors

Changes shall be assessed according to a four-level evaluation system for determining the quantity of work prior to quotation:

Ⅰ Level (Interface Layer): Only the external interfaces or communication methods are replaced; the structure and transmission system remain unchanged, and the quotation is based on standard configuration;

Ⅱ Level (parameter level): Adjustments to the dimensions, stroke, or material parameters of the same module; revision of drawings without introducing any new validation items;

Ⅲ Module level: When adding or replacing a module code, a single-module validation and joint integration testing must be performed;

Ⅳ Level (structural level): Changes in the cabin configuration or load-bearing structure require a new structural and overall aircraft validation.

The corresponding cycles and costs at each level shall be determined based on project-based scheduling; the quotation document shall specify the applicable level.

Modification level	instance	Impact on the cycle	Impact on costs
Zero modifications	Select ●-level modules + standard environment package	benchmark	benchmark
parameterization	Size range adjustment, stroke adjustment, and custom appearance	low	low
module level	New drive configurations, new active functions, and a significant increase in protection rating (IP54 → IP65)	Medium–High	Medium–High
System-level	New forms (e.g., containerized systems, indoor machine rooms); cross-category applications (robotic dogs/unmanned vessels)	Big	Big

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2.6 Chapter Summary and Reading Guide

The framework established in this chapter will be developed in the subsequent chapters:

Framework Elements	Expand Chapter
L0 Hull Structural Layer	Chapter 5: Environmental Adaptability Design

Framework Elements	Expand Chapter
L1 Drive Execution Layer + Three-Motion Module Architecture	Chapter 3 (the longest chapter in the book)
L2 Electrical Energy Layer	Chapter 4
L3: Control Layer of the Perceptual Layer	Chapter 6
L4 Interface Protocol Layer	Chapter 7 (Most Important for Developers)
L5 Delivery and Operations Layer	Chapter 9 (RFI and Decision Trees), Chapter 10 (Case Study)
Reliability evidence	Chapter 8
Evolutionary direction	Chapter 11

Recommended pathways for three types of readers:

Integrators/Developers: This chapter → Chapter 7 (Interface Protocols; focus on reading 7.4 "Register Mapping" and 7.9 "Integration Guidelines") → Chapter 6, Section 6.9 ("Software Product Lines and Source Code Delivery") → Chapter 9.

Structural Engineer: This chapter → Chapter 3 (focus on sections 3.4–3.6 on three-link mechanisms and section 3.8 on linkage timing) → Chapter 5 → Chapter 9, Section 9.2 (RFI Categories 2 and 3).

Electrical Engineer: This chapter → Chapter 4 (focus on Section 4.4, Power Budget) → Chapter 7, Section 7.4 (Register Scaling Rules) → Chapter 8, Section 8.4 (EMC and Safety Testing).

This chapter contains two key gaps that readers should be aware of: the absence of a quantitative definition for size ranges (2.3.3) and the absence of code-by-code maturity assessments for active modules (2.4.2). These two issues directly affect the autonomy in component selection; once the HEISHA issue has been addressed, the relevant tables in this chapter will be updated.

Charpter 3 L1 Drive Execution Layer: Three-Motion Module Architecture

3.1 From "redesigning each order" to "modular combination"

3.1.1 Sources of mechanical complexity in custom-built hangars

A UAV hangar is not merely a simple box-shaped container; it is a mechatronic

system that integrates multiple types of motion mechanisms. From a functional perspective, a hangar must at least perform the following mechanical operations: opening and closing the cabin door (including sealing), positioning and moving the UAV within the cabin (centering, lifting and lowering, etc.), and carrying out functional operations for the UAV (battery swapping, propeller replacement, pitch adjustment, etc.). Each type of operation involves a series of engineering considerations, including motor selection, reduction ratio calculation, limit-position design, synchronous control, and sealing interfaces. When these operations are combined, the mechanical complexity grows exponentially—spatial interference between different transmission methods, sequential interlocking, and fault linkage all require individual verification.

Under the traditional custom development model, the aircraft nacelle for each project is designed from scratch. Engineers must reconfigure the nacelle structure, select a transmission solution, draw technical drawings, prepare a BOM, build a prototype, and conduct commissioning and integrated testing based on the drone model specified by the customer, the deployment environment, and the functional requirements. The costs associated with this model are reflected in three areas:

Long cycle times: From requirements confirmation to prototype delivery, each project must complete a full cycle of mechanical design, trial production, and validation. Structural design and trial production typically occupy the majority of the project timeline, while validation and field commissioning depend on the completion of the complete machine; consequently, the delivery lead time for customized projects depends more on the pace of validation than on manufacturing capacity.

High costs: Non-standardized design means that validated drawings and BOMs cannot be reused; material procurement makes it difficult to achieve economies of scale, and assembly processes cannot be standardized; consequently, labor hours and rework typically account for a larger proportion of total costs than the materials themselves.

Reliability is uncontrollable: each redesign introduces new unverified stages, and the on-site failure rate is positively correlated with the number of design iterations. The "Technical Challenges Overcome" list documents dozens of transmission-related issues encountered in actual projects—such as coaxiality deviations in the centering lead screw, missed steps in the pusher motor, and the upper cover scraping the inner side of the support legs during roller operation; the accumulation of these issues has precisely driven the development of modular packaging.

3.1.2 Solution for HEISHA: Three-Dynamic Modular Packaging

Through years of specialized development tailored to the aircraft hangar, all mechanical operations have been abstracted into three categories: door actuation, mechanical actuation, and active actuation. Each category is further modularized and packaged according to the combination of "transmission method × size range"; the drawings and BOM have been finalized, and the associated motors, drives, gearboxes, limit switches, and other components have been fully specified. Customization projects have thus shifted from "redesign" to "module selection + assembly."

The core value of this approach lies in the following:

Verifiability: The drawings and BOMs for each module have been validated through actual implementation across multiple projects; they are no longer merely paper-based proposals.

Predictability: During the component selection phase, the integrator can determine the coding, size range, and interface form of the modules to be used, without having to wait for the detailed design to be completed.

Maintainability: A modularized BOM provides a solid basis for spare-parts management and on-site replacement.

The benefit of modularization lies in predictability: once the requirements are defined, configuration and quotations can be generated from a module catalog; engineering resources can therefore be focused on interface and dimensional adjustments rather than on redesigning the entire machine. The reuse rate varies depending on the type of project—changes to the environmental package and electrical solution generally do not affect the choice of transmission, whereas changes in machine model and cabin configuration directly alter the coding combination for door actuation and machine actuation.

3.2 Three-Action Classification Method: A Complete Exhaustive Catalogue of Aircraft Hangar Mechanical Actions

3.2.1 definition

The definitions of the three movements are as follows:

Door actuation refers to the transmission method used for the hangar door; whenever

a hangar incorporates storage functionality, this component must be custom-made.

Mobility refers to the movement of a drone. Whenever a drone needs to enter its hangar for various operations, a mechanism for its movement must be designed.

"Active capability" refers to certain functional operations of drones, such as battery swapping, equipment replacement, and hydrogen refueling.

3.2.2 Terminology Clarification

In this article, "mobile" specifically refers to "the movement mechanism of a drone within the hangar"; it is a noun-based technical classification term and should not be confused with "mobility" or "flexible dispatch" in everyday contexts. When first introduced, it should be accompanied by a clarifying note; thereafter, this meaning shall be used consistently throughout the text.

3.2.3 Analysis of the Self-Consistency of the Three-Point Shot

The logical boundaries of the Three-Dynamic Classification Method can be understood as follows:

Door actuation = the opening and closing of the cabin boundary. Regardless of the transmission method employed (smooth, rotary, rolling shutter, etc.), its fundamental function is to control the connection or isolation between the interior space of the cabin and the external environment. Door actuation does not involve displacement or functional operation of the UAV itself.

Maneuverability = the displacement of the unmanned aerial vehicle itself. This includes centering and positioning, ascent and descent, translation, magazine storage, and other operations; its fundamental function is to change the UAV's spatial position or attitude within the cabin. Maneuverability does not directly perform functions such as charging or battery swapping.

Actuation = the functional operation performed by a drone. This includes battery swapping, cargo replacement, hydrogen refueling, water replenishment, pitch control, and other activities; its functional essence consists in applying a specific functional operation to the drone. The execution of actuation typically relies on the precise positioning provided by maneuverability as a prerequisite.

There is no functional overlap among the three: the "door-driven pipe" performs switching, the "mobile pipe" performs displacement, and the "active pipe" performs work. A complete hangar operation typically results from the sequential coordination of these three movements.

3.2.4 The Logical Relationships and Interdependencies Among the Three Dynamics

There exists a clear causal dependency chain among the three dynamics:

1. Door operation is a prerequisite for mobility: if the door is not opened, the drone cannot take off or land; if the door is not closed, return to base and charging cannot be carried out safely.

2. Maneuverability serves as the foundation for mobility: dynamic operations such as battery swapping and item exchange require the UAV to land precisely at a designated position, which is ensured by the maneuverability module — particularly its centering function.

3. Activeness is the ultimate objective: the ultimate service recipients of door-based and mobile operations are the execution of active functions (or direct support for the takeoff and landing operations of unmanned aerial vehicles).

This dependency has been empirically validated in the pre_takeoff (one-click pre-flight) step_key sequence of the HEISHA API (see Section 3.8 for details). The sequence of transmission actions defined by the API is as follows: first close the putter (close_putter) → turn on the remote controller (turn_on_rc) → open the canopy (open_cover) → power on the drone (open_drone) → release the putter (free_putter), clearly illustrating the temporal constraints governing the coordinated execution of the three actions.

3.2.5 Figure 3-1: Classification into Three Dynamics and Their Interconnected Relationships

```
graph TD
subgraph gate动作_MD
A[Door Opening/Closing] --> A1[Smooth Double Opening/Smooth Single Opening]
A --> A2 [Double-Open Rotation / Single-Open Rotation]
A --> A3 [Roller/Vertical Roller Shutter]
A --> A4[Raise and rotate/Raise smoothly]
end
```

```
B subgraph Mobile_JD
B Drone displacement] --> B1 [Centering/Asymmetry centering/Gravity centering]
B --> B2 [Translation/Lift]
B--> B3 [Horizontal rotation]
B--> B4 [Vertical Magazine/Rotating Magazine]
end

subgraph Active_ND
C[Functional Action] --> C1[Three-axis battery swap / robotic arm battery swap]
C--> C2 [Three-axis exchange / Height-adjustable exchange]
C--> C3 [Three-axis hydrogenation/water addition mechanism]
C--> C4 [Paddle mechanism]
end

A-- "After the door opens" --> B
B-- "After positioning is complete" --> C
C-- "Function completed" --> B
B-- "After returning to position" --> A

style A fill:#e1f5fe
style B fill:#fff3e0
style C fill:#e8f5e9
```

Figure 3-1 Schematic Diagram of the Three-Dynamic Classification and Their Interconnected Relationships

---

3.3 Coding Scheme and Module Naming Rules

3.3.1 Code Structure Analysis

The three-action module adopts a unified coding system:

class	Letter prefix	Sequence Number Range	Total number of codes
Door movement	MD	01–24	24
motor-driven	JD	01–24	24
active	ND	01–21	21
amount to			**69**

The code consists of two parts: an alphanumeric segment that identifies the category (MD/JD/ND), and a two-digit numeric sequence that identifies the specific module. The sequence is assigned according to a two-dimensional matrix of "transmission method × size class."

3.3.2 2D Matrix: Drive Method × Size Range

Modules within each category are organized along two dimensions:

Operation mode (transmission method): 8 door-driven types, 8 motor-driven types, and 7 actuator-driven types.

Size (size range): Large / Medium / Small, three levels.

For example, MD01 = door actuation + double-opening smooth operation + high setting; JD03 = motorized operation + centering + low setting; ND15 = active operation + robotic arm battery swapping + low setting.

3.3.3 Quantitative criteria for size classes

A three-tier classification ("large/medium/small") is provided, but the basis for quantifying these three tiers is not specified: whether they are categorized according to the wheelbase of the compatible UAV, UAV weight, cabin opening dimensions, or transmission stroke remains unexplained.

The three rating categories are primarily based on the overall dimensions of the unmanned aerial vehicle during takeoff and landing: the small category has a landing gear outer dimension $\leq$500 mm and a rotor blade span $\leq$600 mm; the medium category has an outer dimension of 500−900 mm or a rotor blade span of 600−1100 mm; and the large category has an outer dimension $\geq$900 mm or a rotor blade span $\geq$1100 mm. Boundary models are assigned a rating after the net dimensions of the fuselage opening and the centering travel have been verified. The rating values shall be taken from the range accepted for engineering applications; for HEISHA, the rating shall take effect after being

verified against the actual coverage area specified in the module atlas.

Recommended method for defining size ranges (the following is for recommendation only and does not reflect factual information):

Size range	Recommended definition basis	Reference range of compatible device models
small	Drones with a compatible wheelbase ≤ 400 mm or takeoff weight ≤ 2 kg	Mavic 3E/T, Matrice 4E/T, etc.
Midum	Suitable for drones with a wheelbase of 400–700 mm or a takeoff weight of 2–8 kg	Matrice 350 RTK, M30, etc.
big	Drones with a compatible wheelbase> 700 mm or takeoff weight> 8 kg	Matrice 400, Ark 20, vertical takeoff fixed-wing aircraft, etc.

The above is merely a sample framework; the actual tiering thresholds should be determined by Heisha based on the practical experience gained from the adaptation of existing products.

3.3.4 Unified terminology for coding and naming

In the Active Module Table, the naming dimensions across the rows are inconsistent:

"Three-axis battery swap," "Three-axis vehicle exchange," "Three-axis hydrogen refueling" —named according to the number of axles

"Cargo Loading & Unloading" — named after the mode of operation

"Robotic Arm Battery Swapping" — Named according to the type of mechanism

"Water intake mechanism" and "paddle collection mechanism" — named according to their functional targets

It is recommended that a standardized naming format of "activity type/institutional form + functional movement" be adopted, for example:

Original Name	Recommended Name	Naming Logic
Three-axis battery swap	XYZ Platform Battery Swap	Exercise Type + Function
Three-axis replacement	XYZ Platform Exchange	Exercise Type + Function
Three-axis hydrogenation	XYZ Platform Hydrogen Refueling	Exercise Type + Function
Height adjustment and exchange	Exchange for lifting platform	Exercise Type + Function
Robotic Arm Battery Swapping	Robotic Arm Battery Swapping	Institutional Form + Function (Already Met)
Water addition mechanism	Add water at the designated point	Exercise Type + Function
Paddle mechanism	Rotary rudder	Exercise Type + Function

Standardized naming helps integrators quickly understand the motion characteristics

of modules and reduces communication costs associated with component selection.

3.3.5 Version Identification and Extension Process

The current coding system does not include version identifiers. As products iterate, modules associated with the same code may undergo design changes (for example, the fix for the DCAP V3 centering, lifting, and derailment issue involved a module redesign). It is recommended that a version number field be added to the coding system, formatted as MD01-R2 (where R2 indicates the second revision), or that version history be documented in the BOM.

At the same time, it is recommended that the expansion process for the new module be clearly defined: when the existing 69 codes are insufficient to cover new transmission requirements, how to apply for a new code, how to assess whether the code should be included in the standard module library, and how to update this document.

3.4 Door actuator module MD01–MD24

3.4.1 Complete coding table

driving mode	big	Midum	small
Double smoothness	MD01	MD02	MD03
Single-opening smoothness	MD04	MD05	MD06
Double-opening rotation	MD07	MD08	MD09
expansion cylinder	MD10	MD11	MD12
Single-opening rotation	MD13	MD14	MD15
Lift and rotate	MD16	MD17	MD18
Smooth elevation	MD19	MD20	MD21
Vertical roller shutter	MD22	MD23	MD24

Definition: "Door actuation refers to the method by which a hangar door is driven; wherever a hangar has storage functionality, this component must be custom-made. Through years of experience in hangar customization, Heisha has modularly packaged the various types and dimensions of door actuation; the drawings and BOMs have been finalized, and the associated motors, drives, gear reducers, limit switches, and other components have been fully specified. Moreover, the cover-opening methods described above essentially provide comprehensive coverage for the diverse customization requirements of various hangars."

3.4.2 Principles of Mechanisms for Eight Transmission Methods

The operating principles of the eight types of door mechanisms are described below in detail. Stroke, driving torque, and motor power vary with changes in size class and cabin dimensions; these fall within the scope of values specified in the module drawings and configuration lists. This section outlines the mechanism composition, actuation logic, and applicable boundaries; specific parameters shall be subject to the module drawings.

（1）Double smooth (MD01/MD02/MD03)

Two 舱 doors slide open and close symmetrically in a horizontal direction, resembling a sliding-door mechanism. Their motion follows a straight-line translation path and is typically driven by an electric push rod or lead screw; the two sides are linked via a synchronous belt or a gear rack and pinion system.

Typical structural components: guide rail, slider, electric push rod/screw lead screw, synchronous linkage, limit switch, and sealing gasket.

Travel distance and space occupancy: The opening travel distance is approximately equal to the width of a single door; door panel storage space must be provided on both sides of the cabin. When closed, the door panel is flush with the cabin wall, resulting in high space utilization.

Sealing fit: The door panel edge is embedded in a sealing groove, which provides a seal through clamping force when the door is closed. The D65 product features a "dual-opening automatic door" equipped with a synchronous drive mechanism, ensuring smooth opening and closing and low noise; it also supports emergency manual unlocking in the event of a malfunction, serving as a demonstration of this design approach.

Applicable scenarios: Small and medium-sized ground hangars where sealing performance and surface smoothness are required.

Trade-offs: The advantages include a mature structure, excellent sealing performance, and a clean appearance; the disadvantages are that sliding clearance must be provided on both sides, and the installation space in the width direction of the hull is relatively large.

Compatible model: D65. It is explicitly described as a "dual-opening automatic door," i.e., a dual-opening smooth operation. The two doors translate in opposite directions simultaneously, opening outward from the center; this design is suitable for models with a relatively large cabin width and requirements for a shorter opening travel.

（2）Single-opening smooth (MD04/MD05/MD06)

A single door slides open and closed horizontally; its operating principle is the same as that of a smoothly opening double door, but only one door leaf moves. It is suitable for scenarios in which there is a fixed wall on one side of the cabin or where opening only on one side is required.

Typical structural configuration: Similar to the double-open smooth type, but featuring only one set of drive mechanism and one set of guide rails.

Travel distance and space requirements: The door-opening travel distance equals the full width of the door panel; complete storage space must be reserved on each side.

Sealing fit: The movable door panel and the fixed wall surface are joined via a sealing strip.

Applicable scenarios: wall-mounted installation, side-mounted openings in vehicles, and single-sided operation in space-constrained environments.

Trade-offs: The advantages are a simple structure and low cost; the disadvantages are a large door opening travel and significant space occupancy on one side.

Applicable boundary conditions: single-sided openings with limited access depth to the facility, such as integrated server room configurations and side-mounted installations against a wall. The single-panel sliding mechanism has a simple structure; the net opening is constrained by the width of the door leaf, so the enclosure width should not be excessively large.

（3）Double-Open Rotation (MD07/MD08/MD09)

The two doors rotate outward on hinges, opening and closing in a manner similar to a conventional swing-door configuration. They can be driven by an electric push rod or a rotary motor.

Typical structural components: hinge, electric push rod/rotary motor, limit switches, and sealing strips.

Itinerary and spatial occupancy: When the door is opened, the door panel extends outward, occupying the peripheral space around the cabin. For the D65, the "door-extended outer contour length of 1288 mm" and the "maximum length in the extended state of 1570 mm" can serve as reference values for the door-extended space.

Sealing fit: When the door panel is closed, sealing is achieved through the sealing strips on the hinge side and the movable side.

Applicable scenarios: Situations requiring a wide opening, or scenarios where there are strict limitations on the storage space within the door panel (the door panel is extended outward rather than retracted inward).

Trade-offs: The advantages are a large opening and an intuitive structure; the disadvantages are that the outward extension occupies external space and that the door panel experiences greater stress in high-wind conditions.

Applicable scenario: Ground-based fixed hangars that require a large net opening within a limited opening travel range. The door leaf rotates around a side axis to swing outward; the net opening is determined by the door leaf width, and the swing radius must allow for sufficient site space.

（4）Drum (MD10/MD11/MD12)

The door is stored within the drum in a coiled configuration, similar to a rolling shutter door; however, it is typically formed by coiling a single rigid panel or by segmental folding. The packaging list for the D80 includes "T3 connection drum, 12-core power and signal cable" and "T3 connection drum, RJ45 2-terminal aviation plug cable," indicating that the D80 employs a drum-based door mechanism and that the drum module integrates independent communication and power interfaces.

Typical configuration: drum shaft, drive motor, reducer, rainproof cover plate, limit switch, and RS485 communication module.

Route and space footprint: The door panels are coiled and stored in a drum at the top or bottom of the cabin, without occupying side space. This solution is suitable for scenarios where cabin width is limited.

Sealing fit: The edge of the door panel is sealed against the guide rail using a brush or rubber strip.

Applicable scenarios: compact hangars, vehicle-mounted hangars, and other applications where lateral space is a critical constraint.

Trade-offs: The advantage is that it saves lateral space and provides compact storage; the disadvantage is that its airtightness is relatively weaker, and the drum mechanism occupies vertical space within the cabin.

Device model data indicate that the drum module features an independent state enum (0x00 UNKNOWN / 0x01 CLOSED / 0x02 OPENED / 0x03 ERROR (deprecated) / 0x04 OPENING / 0x05 CLOSING / 0x06 FAULT), limit switch status (Bit0: limit open; Bit1: limit closed), temperature and humidity monitoring, tethering status monitoring,

and a comprehensive set of command codes (resetting the rain cover, opening/closing the rain cover, stopping, MCU reset, high-voltage tethering control, reel-position control, etc.). This demonstrates that the drum module not only performs door-motion functions but also integrates environmental sensing and tethering management capabilities, making it a highly integrated module.

Compatible model: For the D80, the door operates via a drum mechanism, with the door body wound and stored in the upper section of the cabin. This design does not occupy lateral space and is suitable for installations with limited side space and a requirement for vertical clearance for opening.

（5）Single-opening rotation (MD13/MD14/MD15)

A single-door door opens and closes by rotating outward about a hinge; its structure is similar to that of a double-door swing door, but only one side is mobile. It is suitable for single-sided operation or asymmetric cabin designs.

Typical structural components: hinge, electric push rod/rotary motor, limit switches, and sealing strips.

Motion and spatial occupancy: Similar to the double-opening rotation, but with abduction on only one side.

Applicable scenarios: maintenance doors, auxiliary openings, and asymmetrical aircraft hangars.

Pros and cons: The advantage is its simple structure; the disadvantage is uneven load distribution on one side, and for large door panels, attention should be paid to the strength of the hinges.

Applicable scope: miniaturized and in-vehicle applications. The single-panel outward-opening structure occupies minimal space during operation, making it suitable for scenarios where cabin width is limited but a large unobstructed opening is required.

（6）Lifting and rotation (MD16/MD17/MD18)

The door first rises to a certain height and then rotates open. This combined motion enables the creation of a large opening within a limited horizontal space while preventing the door panel from directly extending outward and colliding with surrounding obstacles.

Typical structural components: lifting guide rails, rotating hinges, a two-stage drive mechanism (lifting + rotation), and limit switches.

Travel path and spatial footprint: A lifting travel path must be reserved in the

vertical direction; the horizontal swing range is smaller than that of a pure rotary door.

Sealing fit: The seals in the lifting section and the rotating section must be addressed separately, resulting in a relatively complex structure.

Applicable scenarios: scenarios where there are obstacles around the cabin, or where a large opening needs to be achieved within a confined space.

Trade-offs: The advantage is its strong adaptability to spatial constraints; the disadvantages are a complex structure, greater sealing challenges, and higher costs.

Application scope: First lift the sealing surface to disengage it, then rotate the outer swing; this significantly reduces frictional wear between the door body and the sealing strip, making it suitable for high protection ratings (IP65) and high-frequency opening and closing conditions.

（7）Elevated and smooth (MD19/MD20/MD21)

The door first rises upward and then slides horizontally to open, operating on a principle similar to that of garage lift doors. The D135 has an opening dimension of 1638 ×1251×1037 mm and a closed dimension of 1638×1251×1599 mm—the closed height being greater than the opening height—indicating that the door panel remains in the raised position when closed; after opening, the door panel descends and slides into the storage position, which is consistent with the characteristic of smooth lifting motion.

Typical structural components: vertical guide rails, horizontal guide rails, lifting drive, translation drive, limit switches, and sealing strips.

Travel path and spatial footprint: A lifting travel path must be reserved in the vertical direction, while sliding storage space must be reserved in the horizontal direction.

Sealing fit: The door panel achieves sealing through vertical clamping force when in the closed position.

Applicable scenarios: Situations requiring a top seal and limited lateral space.

Trade-offs: The advantages are excellent sealing performance and a large opening; the disadvantages are that the two-stage drive increases the mechanical complexity and the number of potential failure points.

Compatible model: D135. Based on the variation in its closed and open dimensions, it is classified as having smooth lifting behavior. The door first lifts vertically to disengage from the sealing surface, then slides horizontally into storage, thereby balancing sealing longevity with net opening width.

（8）Vertical roller blinds (MD22/MD23/MD24)

The flexible or segmented rigid curtain surface rises and descends vertically for opening and closing, similar to an industrial roller shutter. The curtain surface is wound and stored within a reel located at the top of the cabin.

Typical structural components: roller, drive motor, curtain fabric, guide rails, and limit switches.

Travel and space footprint: The curtain panel rises and descends vertically and is stored within the top roller, leaving no space occupied on the sides or at the bottom.

Sealing fit: The curtain surface and the guide rail are sealed using a brush or rubber strip; the sealing performance depends on the material of the curtain surface and the precision of the guide rail.

Suitable applications: Large aircraft hangars, containerized aircraft hangars, and other scenarios requiring large openings and compact space.

Trade-offs: The advantages include a large opening, compact storage capacity, and a simple structure; the disadvantages are relatively weaker sealing performance and wind-pressure resistance.

Applicable configurations: elongated cabin bodies and container-shaped layouts. The rolling shutter operates vertically and rises and falls independently, requiring no longitudinal space; it is therefore suitable for layouts where the cabin's clear height is limited while the opening width is relatively large.

3.4.3 Opening and Closing Dimension Comparison Table

The following is a summary of the opening and closing dimensions for each known product; these data provide empirical evidence for the required door travel and spatial requirements:

Product	Closing dimensions (L×W×H, mm)	Open dimensions (L×W×H, mm)	Dimensional variation characteristics
D80	1109×900×1020	1109×900×558	Height reduced by 462 mm (the drum is stored at the bottom)
DCAP	1320×880×400	2020×880×400	Length increased by 700 mm
D65	672.8×664×645	Maximum expansion length: 1570	Total width when both side doors are fully open
D200	—	—	Opening and closing dimensions shall be subject to those specified in the product drawings.
D135	1638×1251×1599	1638×1251×1037	Height reduced by 562 mm (moves downward after the door panel is raised)

Product	Closing dimensions (L×W×H, mm)	Open dimensions (L×W×H, mm)	Dimensional variation characteristics
D250	2500×2400×1500	4600×2400×1500	Length increased by 2,100 mm (nearly doubled)
D100	1200×890×1034	1200×890×710	Height reduced by 324 mm
D90	1550×1550×1740	—	Dimensions vary according to the door type and opening travel; please refer to the product drawings for the specified dimensions.
DCAP PRO	1850×1050×356	2850×1050×356	Length increased by 1000 mm
DCAP MINI	1360×750×280	1360×1480×280	Width increased by 730 mm
DCAP LITE	710×650×330	1320×650×330	Length increased by 610 mm

Note: For D65, "maximum unfolded length: 1570 mm" refers to the total width when both side doors are fully opened; "net working length of the operating area: 846 mm" refers to the length of the effective working space inside the main body of the hangar; and "outdoor outline length when doors are unfolded: 1288 mm" refers to the outdoor outline dimensions after the doors have been opened, excluding the base.

The dynamic parameters of the door (opening/closing time, driving torque, and motor power) vary with the size class and the dimensions of the cabin: for the D65 cabin, the opening and closing time is ≤30 seconds per cycle (single door); for all other models, the value shall be taken from the module drawings. In the configuration list, "maximum opening/closing time" shall serve as the acceptance criterion; on-site acceptance shall be performed by timing a complete cycle.

3.4.4 Key Engineering Elements of Door Operation

Synchronous Drive: D65 explicitly mentions a "synchronous drive mechanism" to ensure that the movements on both sides of the double doors are synchronized. For smooth double-opening and double-opening rotation, synchronization is critical to preventing door panel jamming and sealing failure.

Limit detection: Data from the physical model indicate that the limit switch status of the drum module includes Bit0 (open limit) and Bit1 (closed limit); a bit value of 0 means the limit has not been triggered, while a value of 1 means it has been triggered. This indicates that the door actuation module has limit detection capability, enabling the control system to determine whether the door panel has reached its target position.

Emergency manual door release is a safety feature for door operation: D65 enables manual opening of the compartment door during a power failure or motor

malfunction. This function is recommended as a standard safety feature for outdoor models and should be included in the on-site acceptance criteria (see 8.8.2); acceptance shall be carried out by manually opening the door once after power is disconnected and confirming that the sealing mechanism has returned to its original position.

Sealing structure: D90 mentions that "the multi-stage door sealing structure forms an independent airtight compartment upon closure, providing multiple barriers against dust, water, and salt spray," as well as that "the openings are constructed from PTFE material, which effectively withstands a wide range of low-temperature and high-temperature environments and prevents deformation." This indicates that the sealing design of the door actuator module must account for material deformation under extreme temperatures.

State enumeration: The API defines a cover_state enumeration (D series): 0 = closed, 1 = open, 2 = partially open, 3 = fault, 9 = unknown. The drum module's state enumeration is more granular: 0x00 UNKNOWN / 0x01 CLOSED / 0x02 OPENED / 0x03 ERROR (obsolete) / 0x04 OPENING / 0x05 CLOSING / 0x06 FAULT. Note that drum states include transitional states (OPENING/CLOSING), whereas the D-series cover_state provides only "partially open" as an intermediate state.

Differences in state enumeration reflect the varying requirements for control granularity across different door actuation modes: because the winding process in drum-type door actuators is continuous, it is necessary to distinguish between the transitional states of "opening" and "closing"; in contrast, the intermediate positions of smooth/rotary door actuators are relatively discrete and can be adequately represented by the term "half-open."

3.4.5 illustrating picture

D65 Hangar Real-Photo Image

D65 Hangar Real-Photo Image

Figure 3-2: D65 double-leaf automatic door structure (Image source: Heisha Product Documentation)

Actual image of the D250 hangar

Actual image of the D250 hangar

Figure 3-3 D250 hangar (the length increases from 2500 mm to 4600 mm after the hatch is opened, demonstrating the dynamic characteristics of the long-stroke door)

D135 Hangar photograph

D135 Hangar photograph

Figure 3-4 D135 hangar (closed height: 1599 mm; open-door height: 1037 mm; vertical travel of the display-lift type door mechanism)

3.5 Mobile Modules JD01−JD24

3.5.1 Complete coding table

driving mode	big	Medium	small
Return to the center	JD01	JD02	JD03
Return bias	JD04	JD05	JD06
Translation	JD07	JD08	JD09
promotion and demotion	JD10	JD11	JD12
Horizontal rotation	JD13	JD14	JD15
Vertical magazine	JD16	JD17	JD18
Rotating magazine	JD19	JD20	JD21
Gravity Realigns	JD22	JD23	JD24

Definition: "Mobility refers to the movement of a drone. Whenever a drone needs to enter its hangar for various operations, a mobility mechanism must be designed. Through years of experience gained from custom hangar solutions, Heisha has modularized and packaged the various mobility methods and dimensions; the drawings and BOMs have been finalized, and the solution essentially covers a wide range of customization scenarios."

3.5.2 Principles of Mechanisms for Eight Transmission Methods

The operating principles of the eight actuation mechanisms are described below in detail. The key parameters of the actuation module are centering accuracy, centering force, and centering speed; these three parameters are strongly coupled with the aircraft type and its landing gear configuration. This section describes the mechanical configuration and actuation logic; specific parameters shall be subject to the module drawings.

（1）Return to Center (JD01/JD02/JD03)

Centering is the most critical maneuver performed by the drone. After the drone lands on the apron, because landing accuracy is limited (even when using RTK,

horizontal error can still be on the order of centimeters), a centering mechanism is required to precisely push the drone into the designated standard position for charging or storage. Centering accuracy directly determines the reliability of contact engagement during charging; excessive deviation may cause contact misalignment, charging failure, or even a short circuit.

Typical structural configuration: centering rod/centering claw, lead screw or push rod drive, guide rail, limit switch, and charging electrode plate.

Operation: The centering lever tightens from the periphery toward the center, pushing the drone's tripod into its standard position; when released, the lever moves in the opposite direction, allowing the drone to take off.

Key indicators: centering accuracy (measured by the deviation when the landing gear falls into its designated position), centering force (the force that must be overcome to counteract the drone's own weight and friction at the contact surface), and centering speed (which affects the cycle time per operation). These three parameters must be compatible with the type of landing gear used by the aircraft; acceptance shall be based on the success rate of charging contact after centering.

Centering Rod State Machine: The object model defines a complete enumeration of the centering rod states:

Condition code	meaning	Project Interpretation
0x00	UNKNOWN	Power-on initialization or communication interruption; status unknown
0x01	UNLOCKED	The return mast is fully released, allowing the drone to take off and land freely.
0x02	LOCKED	The return rod is fully retracted, and the drone locks into its standard position.
0x03	LOCKING_STEP1	Return to Normal: Tightening Phase I
0x04	LOCKING_STEP2	Narrowing the scope of the second phase
0x05	UNLOCKING	During the release process from the nucleus
0x06	FAULT	fault condition

LOCKING is divided into two steps — STEP 1 and STEP 2 — indicating that centering locking is a staged process. From an engineering perspective, the first step may involve coarse positioning (pushing the drone to a rough position), while the second step involves fine positioning (making fine adjustments until the charging contacts are precisely aligned). The advantage of a staged design is that if an abnormal resistance is detected during the first step—for example, if the drone has not landed correctly—the process can be stopped promptly rather than being forced forward, thereby preventing damage to the drone or the centering mechanism.

Centering command code: The object model defines the command code scheme for the centering module:

command code	Function	Remarks
1	Status Reset	Clear fault indicator
2	Narrowing the return	Execute and return to lock
3	Release upon return to the center	Release the return rod
4	Stop	Emergency stop current operation
21	Reset window	Return the small window to its default position
22	close the window	Close the secondary window
23	window	Open the Guizhong window
24	Stop Window	Stop the small-window action
71	Slurry collection action 1	Phase 1 of the rowing stroke
72	Slurry collection action 2	Second phase of rowing

It is worth noting that the command codes of the centering module not only include the control functions inherent to centering itself (command codes 1−4), but also integrate "window" control (21−24) and "paddle retraction" control (71−72). This indicates that the centering module reuses control resources at the hardware level: the centering board simultaneously performs the control functions for centering positioning, small-window opening and closing, and paddle retraction. This functional reuse reduces the number of control boards, but also means that the firmware of the centering module is relatively complex.

Limit switches: The object model indicates that the trigger status of the limit switches in the centering module is Bit16-0, with a total of 17 limit points. The presence of 17 limit points indicates that the centering mechanism employs multi-point detection, which may include: the extreme positions in the four directions of the centering rod, the intermediate position, and alignment detection of the charging electrode, among others. Multi-point detection provides fine positional feedback during the centering process and serves as the hardware foundation for implementing staged locking (STEP1/STEP2).

（2）Return Bias (JD04/JD05/JD06)

Centered offset placement is similar to centered placement, but rather than moving the UAV toward the center, it positions it at an offset location on one side. It is suitable for scenarios in which the cabin layout is asymmetrical, or in which the UAV needs to be stationed at a specific work station (e.g., a tool-changing station or inspection station).

Typical structural configuration: Similar to the center-return type, but with a unidirectional or eccentric guiding direction.

Applicable scenarios: multi-station battery swap bays and dedicated battery swap/vehicle swap stations.

Applicable to aircraft with asymmetric landing gear or an offset center of gravity: the trim mechanism is adjusted to center using one side as the reference; the structure is simpler than that of a centering mechanism, but space must be reserved within the cabin for the trim travel range.

（3）Translation (JD07/JD08/JD09)

The UAV moves in a straight horizontal line within the cabin to facilitate transfers between different workstations.

Typical structural configuration: linear guide, lead screw or belt drive, and load platform.

Application scenario: Transfer of drones between stations in a multi-station hangar, from landing and charging to charging and storage.

Applicable boundary: Arrangements in which the vehicle must travel between the centering position and the charging position within the compartment, such as dual-workstation battery depots and battery-swapping front-end stations.

（4）Lifting (JD10/JD11/JD12)

The UAV moves vertically within the cabin to facilitate transfers between workstations at different heights, or to lift the UAV from its landing position to a charging or storage position.

Typical structural configuration: vertical guide rails, screw or chain drive, and lifting platform.

Applicable scenarios: multi-level storage hangars and designs that require the apron and charging stations to be separated. The D90 explicitly states "built-in centering apron and lift," indicating that the D90 employs both centering and lift as mobility modes.

Compatible model: D90. Equipped with a lift mechanism that raises the drone from its cabin to the plane of the door opening, enabling vertical egress from the cabin in conjunction with the four-slope sloped roof structure.

（5）Horizontal rotation (JD13/JD14/JD15)

The drone rotates around a vertical axis inside the cabin to adjust the orientation of its nose. For vertically takeoff-fixed-wing drones, the nose orientation must align with the takeoff direction; therefore, nose calibration must be performed inside the cabin.

Typical structural components: rotary bearing, rotary motor, angular encoder, and locking mechanism.

Applicable scenario: Hangar for tiltrotor fixed-wing drones. The descriptions of the D330 and V200 mention "head-direction calibration to center," which may involve horizontal rotational maneuvers.

The API contains the rotate_motor_stop and rotate_motor_position commands, as well as a rotate_motor_state status (0 = off, 1 = on), which confirms the presence of a rotating motor.

Compatible aircraft: D330/V200. It features "nose-direction calibration"; after adjusting the nose orientation via horizontal rotation before exiting the launch chamber, it meets the takeoff-direction requirements for vertical takeoff fixed-wing aircraft.

（6）Vertical magazine (JD16/JD17/JD18)

Multiple drones are stacked vertically for storage, and each unit is retrieved and returned one by one in a manner analogous to loading a magazine. This solution is suitable for scenarios in which multiple drones need to be accommodated within a limited footprint.

Typical structural components: vertical guide rails, lifting brackets, locking/release mechanism, and position detection.

Applicable scenarios: multi-machine storage facilities and logistics transfer stations.

Applicable scope: vertical storage modules for multi-unit storage systems. The vertical magazine enables layer-by-layer lifting and retrieval of drones, thereby increasing storage density while maintaining the same footprint.

（7）Rotating magazine (JD19/JD20/JD21)

Multiple drones are arranged in a circular pattern around a central axis; through rotation, the target drone is moved to the pick-and-place station. This operates on the same principle as a rotary rack.

Typical structural configuration: rotating main shaft, annular bracket, rotary drive, and workstation locking mechanism.

Applicable scenarios: Multi-machine storage environments requiring rapid switching.

Applicable scenario: multi-unit storage in circular or near-square modules. The

rotating module position rotates the target module position to the egress port, making it suitable for scenarios with a large number of module slots.

（8）Gravity Re-centering (JD22/JD23/JD24)

By leveraging gravity and inclined or conical surface structures, drones can achieve self-aligning centering without active actuation. When a drone lands on a conical or funnel-shaped landing pad, it slides into the center position by virtue of its own gravity.

Typical structural components: conical/sloped apron, guide slot, and cushion pad.

Applicable scenarios: Applications requiring lightweight construction and low power consumption. The D007 suitcase-style aircraft hangar explicitly states that it features a "completely new gravity-based centering design, which further reduces the overall weight," confirming the use of gravity-based centering.

Trade-offs: The advantages are zero power consumption, zero failure rate, and lightweight design; the disadvantage is that the centering accuracy is significantly affected by the shape of the drone's leg assembly, making it unsuitable for heavy-duty drones.

FAQ: Key Considerations for Customization — Category 2 explicitly mentions the "centering method (gravity or push rod)," indicating that gravity centering and push-rod centering represent two primary technical approaches to centering.

Corresponding model: The D007 employs gravity-based centering, relying on the tilt of the airframe and gravity to allow the UAV to slide automatically into its designated position; its mechanism contains no powered components and offers high reliability. The DCAP MINI adopts a similar approach to reduce the mechanical volume of the vehicle-mounted model.

3.5.3 Coupling between return and charging

The centering mechanism is closely coupled with the charging system. Custom DPAD centering charging boards are a specialized customization project, demonstrating that the centering board and charging board can be designed as an integrated unit.

The patent "An electrode arrangement structure for a centering mechanism in a drone charging platform" (CN210838982U, patent rights in force) further confirms the integrated design concept of combining centering with charging: the arrangement position of the charging electrode and the motion trajectory of the centering mechanism must be designed in coordination to ensure that, once the centering mechanism has reached its target position, the electrode is precisely aligned.

The FAQ's considerations for customization also mention "contact charging stability (centering drive)" and "compatibility (centering)," indicating that the precision and compatibility of the centering drive directly affect charging reliability.

3.5.4 Real-world engineering challenges

The following issues are recorded from the "Technical Issues to Be Resolved" list that are directly related to mobility. The issue descriptions are reproduced verbatim; the key actions for resolution are summarized according to engineering logic. These constitute analytical explanations rather than the final solution for HEISHA.

Problem description	Products involved	Nature of the issue
The coaxiality of the DCAP centering screw is deviated.	DCAP	accuracy of manufacture
DCAP V3 Centering, Lifting, and Trailing	DCAP V3	architectural design
Return to the central pole	Not specified	Institutional Reliability
Release upon return cannot be stopped	Not specified	control logic
D250 pusher motor step loss	D250	Motor Selection/Drive
D135 centering motor fails to move	D135	Insufficient driving force
D135: The centering push rod is slightly tilted, resulting in poor contact.	D135	assembly precision
D250 Centering Wheel Interference Tripod	D250	Spatial Interference
D135: Contact issues during centering	D135	Charging coupling
After D135 returns to center, it returns to the top again within half a minute.	D135	control logic
DCAP V3 M4E fails to release the centering mechanism during charging.	DCAP V3	Charge – Return to Interlock
D135 motor alarm: false alarm indicating cover open status	D135	Status Reporting

The common issues identified above point to two aspects: first, the coupling accuracy between the return mechanism and the charging interface (coaxiality, stroke consistency, and contact pressure); and second, the power supply and communication margins when multiple devices operate concurrently. These two aspects have been established as fixed verification items for iterative iterations of the mobile module (see 8.8.1).

3.5.5 illustrating picture

D90 Hangar Interior Layout

D90 Hangar Interior Layout

Figure 3-5 D90 Ultra-Cold Ultra-Dust Hangar (equipped with an integrated centering apron and a lifting mechanism; apron dimensions: 800×800 mm)

D90 Hangar Details

D90 Hangar Details

Figure 3-6 D90 System Topology (illustrating the position of the centering mechanism within the system)

D90 Hangar Details

D90 Hangar Details

Figure 3-7: D90 Product Specifications

D90 Hangar Details

D90 Hangar Details

Figure 3-8 D90 Product Specifications (Continued)

D90 Hangar Details

D90 Hangar Details

Figure 3-9 D90 Product Specifications (Continued)

D90 Hangar Details

D90 Hangar Details

Figure 3-10: Optional D90 expansion configurations

D90 Hangar Details

D90 Hangar Details

Figure 3-11 D90 Optional Expansion Configurations (Continued)

D90 Hangar Details

D90 Hangar Details

Figure 3-12 D90 Optional Extended Configuration (Continued)

D90 Hangar Details

D90 Hangar Details

Figure 3-13 D90 Optional Extended Configuration (Continued)

D90 Hangar Details

D90 Hangar Details

Figure 3-14 D90 Optional Extended Configurations (Continued)

3.6 Active Modules ND01−ND21

3.6.1 Complete coding table

driving mode	big	Midum	small
Three-axis battery swap	ND01	ND02	ND03
Three-axis replacement	ND04	ND05	ND06
Three-axis hydrogenation	ND07	ND08	ND09
Height adjustment and exchange	ND10	ND11	ND12
Robotic Arm Battery Swapping	ND13	ND14	ND15
Water addition mechanism	ND16	ND17	ND18
Paddle mechanism	ND19	ND20	ND21

Definition: "Activeness refers to certain functional operations of a drone, such as battery swapping, equipment replacement, and hydrogen refueling. Through years of experience accumulated through custom development at the hangar, HEISHA has modularized and encapsulated some of these operations; as the hangar's use cases continue to expand, so do the functional operations, and we will further standardize more actuation modules."

3.6.2 Differences in the maturity of active modules

It must be stated truthfully that, regarding the static and dynamic components, it is said that "the drawings and BOM have already been finalized" and that "the motor, drive unit, reducer, limit switches, and other components have already been finalized"; however, regarding the dynamic components, it is stated that "some configurations have already been modularized and encapsulated... we will further standardize additional transmission modules."

This means that: -The modularization level of the mobile MD01−MD24 and the mobile JD01−JD24 is relatively high; their drawings and BOMs have been finalized. -Among the active ND01−ND21, only some modules have completed finalization; the remainder still require redesign or parametric adjustment as part of the project.

Active modules are subdivided by functional operation, and their maturity advances

incrementally by code based on delivery-based validation: codes with multiple delivery records are considered "cured" (●); codes whose main structure has been finalized and whose travel paths and interfaces require project-specific adjustments are "parameterizable" (◐); and codes based solely on case-based experience require redesign (○). The code-by-code ledger is maintained in accordance with the determination rules specified in 2.4.2; when requesting a quotation, the current level of the selected code can be directly retrieved.

3.6.3 Description of the seven functional movements

The seven functional actions are described in detail below. The actuation module is strongly associated with specific tasks, while the configuration of the mechanism depends on the function it serves (battery swapping, item swapping, refueling, or paddle collection); this section explains the mechanism's composition, action logic, and applicable boundaries.

（1）Three-axis battery swap (ND01/ND02/ND03)

"Three-axis" refers to a XYZ three-axis motion platform, meaning that the battery swapping mechanism can move in three directions to accommodate battery compartments and drone battery interfaces at different positions. A three-axis platform typically consists of three sets of linear motion modules (lead screws or belts), enabling precise positioning in the X, Y, and Z directions.

The trade-off between battery swapping and charging: battery swapping offers a fast turnaround and can support high-frequency operations, but requires additional battery compartment management and battery status monitoring, resulting in a higher level of system complexity; charging has a simple structure and involves no additional assets, but is constrained by charging rates, leading to longer operational intervals. The selection criteria should be based on the average daily number of deployments and battery turnover capacity, rather than on any single cost item.

Applicable scenarios: scenarios sensitive to operation intervals, such as high-frequency inspections and logistics distribution.

Applicable scenarios: elevated secondary scenarios such as logistics transfer and continuous inspection; provided that the project owner is willing to make additional investments in battery assets and battery management.

（2）Three-axis replacement (ND04/ND05/ND06)

Similar to three-axis battery swapping, but with the functional object replaced by cargo loads. It is suitable for drone-based logistics delivery scenarios, in which multiple cargo boxes are stored in a hangar and the target cargo box is loaded onto the drone via a three-axis platform.

•Applicable scenarios: drone logistics transfer stations and delivery terminals.

Applicable scope: logistics and material delivery. The system performs pickup and placement along three axes and is compatible with standardized cargo containers; the interface must be customized in conjunction with the container dimensions and gripping method.

（3）Three-axis hydrogenation (ND07/ND08/ND09)

Refuel hydrogen-powered drones with hydrogen fuel. A three-axis platform is used to precisely position the hydrogen refueling nozzle at the drone's refueling interface. Hydrogen-powered drones have long flight endurance, making them suitable for long-endurance inspection scenarios; however, their refueling system involves high-pressure gas piping and safety protection, resulting in greater design complexity than battery swapping.

Application scenarios: hydrogen-powered UAV base stations and long-endurance inspection missions.

Safety considerations: Hydrogen is flammable and explosive; therefore, hydrogen refueling facilities must incorporate explosion-proof design, leak detection and emergency shut-off systems, and be equipped with independent ventilation and static discharge measures. The design of hydrogen refueling facilities must be integrated into the overall review of the facility's explosion-proof plan; this document does not provide separate specifications.

Applicable scope: Dedicated support facilities for hydrogen-powered vehicle models, to be developed as independent projects on a case-by-case basis.

（4）Height adjustment and replacement (ND10/ND11/ND12)

Cargo loading and unloading is achieved via a lifting platform; compared with a three-axis exchange system, this configuration reduces the degrees of freedom in the horizontal direction, resulting in a simpler structure. It is suitable for scenarios in which the cargo interface position is fixed and only vertical alignment is required.

•Applicable scenarios: Logistics loading and unloading at fixed stations.

Applicable scope: Aircraft models that require vertical cargo transfer between storage positions and delivery positions within the cabin. The mechanism is simplified compared with the three-axis solution, resulting in a slightly longer cycle time.

（5）Robotic Arm Battery Swap (ND13/ND14/ND15)

A multi-degree-of-freedom robotic arm is used to perform battery replacement operations. Compared with a three-axis platform, the robotic arm offers greater motion flexibility and can adapt to more complex battery interface positions and orientations. The API includes a machine_arm data structure (a three-axis robotic arm struct), indicating that the T-series products support robotic arm control.

• Application scenarios: Large-scale logistics lockers and battery swap stations compatible with multiple device models.

Applicable scenarios: multi-unit shared storage or scenarios with fixed battery compartment locations. The robotic arm can reuse the same end effector for loading and unloading, offering high flexibility; however, it imposes stricter requirements on control and safety protection.

（6）Water addition unit (ND16/ND17/ND18)

Refuel drones with water or liquid payloads. This is suitable for applications such as agricultural plant protection drones (refueling with pesticides/water) and firefighting drones (refueling with fire extinguishing agents).

Application scenarios: agricultural plant protection and fire emergency response.

Design considerations: sealing and leak prevention of liquid piping systems, level detection, cleaning and drainage, and low-temperature freeze protection. Fluid system components must be designed in coordination with the onboard temperature control system to prevent freezing-induced cracking.

Applicable scope: Models requiring liquid loads for applications such as fire protection and plant protection; customized according to project requirements.

（7）Paddle mechanism (ND19/ND20/ND21)

After the drone is stored in the warehouse, the propellers automatically fold or disassemble, reducing the storage volume and preventing propeller blades from colliding and sustaining damage inside the compartment.

The oar recovery mechanism serves as a typical example of the tripartite integration of "mechanism + patent + agreement":

Component: As one of the active modules, the pitch mechanism has been incorporated into the standardized coding system (ND19/ND20/ND21).

Patents: Invented patent "A UAV Propeller Retraction Mechanism System" (Application No.2022100869473; Grant Publication No. CN114408157B; Grant Date: 2023-12-22; patent rights maintained); utility model "A UAV Propeller Retraction Device and Helipad" (Application No.2024204632300; Grant Publication No. CN222663815U; Grant Date: 2025-03-25; patent rights maintained).

Protocol: The API contains a pulp motor command for pulp collection motor control; its status enum is defined as 0 = unknown, 1 = position 1, 2 = position 2, 3 = position 3, 4 = position 4, 5 = operating, and 6 = error; the centering module command codes are 71 = pulp collection action 1 and 72 = pulp collection action 2. This indicates that the pulp collection action has been integrated into the centering module's control system and is executed in coordination with centering positioning.

The blade-retraction action is integrated into the command code of the centering module (rather than into an independent module), indicating that in the actual product, the blade-retraction mechanism and the centering mechanism are physically adjacent and coupled in terms of control logic. After the UAV has landed, the centering mechanism first positions the aircraft, after which the blade-retraction mechanism folds the blades; these two actions are executed sequentially on the same control board.

3.6.4 Scalability of the active module

It explicitly states: "As the range of aircraft hangar scenarios continues to expand, so will the number of functional operations; we will standardize more drive modules." This indicates that the active module architecture is open, and that future coding extensions (such as ND22 and beyond) may be introduced to address new functional requirements.

Based on the seven existing actuation modes, it can be seen that the actuation modules for HEISHA cover three energy replenishment methods (battery swapping, hydrogen refueling, and water refueling) and two payload operation modes (payload swapping and propeller recovery). As drone application scenarios expand, additional functional operations may also be required, including sensor payload swapping, ammunition loading (for firefighting and security scenarios), and sampling container swapping (for environmental monitoring scenarios), among others.

3.7 Module Maturity Classification (Recommended Framework)

3.7.1 Applicability Statement for the Maturity Indicator

At present, no maturity indicators have been provided on a per-module basis. The three-level maturity classification proposed in this section is a recommended framework designed to help integrators accurately assess the customization cycle and associated risks; it is not a factual statement.

3.7.2 Recommended Level 3 labeling

Characteristic	Meaning	requirement
● Cured	The drawings, BOM, motor/drive/reducer/limit switch, and all other components have been finalized; they can be selected directly.	Clearly state that "the drawings and BOM have both been finalized."
◐ Parametrically adjustable	The main structure has been finalized; however, its dimensions, travel range, or interfaces must be adjusted according to the project requirements.	The "hint" component has been modularly encapsulated.
○ Requires redesign	No off-the-shelf modules are available; the solution must be designed from scratch.	Unmet new needs

3.7.3 Maturity Inference Classification

class	Encoding range	Infer maturity	Basis for inference
Door movement	MD01–MD24	● Cured	"The drawings and BOM have been finalized... they now provide essentially comprehensive coverage of the customization requirements for various hangars."
motor-driven	JD01–JD24	● Cured	"The drawings and BOM have been finalized and essentially cover a wide range of customized scenarios."
active	ND01–ND21	◐/○ mixing	"Some approaches have already been modularized and encapsulated... We will further standardize more drive modules."

The above table, when expressed at the family level and summarized through delivery-based validation, constitutes an engineering judgment: for door motion and mechanical motion, complete drawings and a BOM are already available; therefore, they should be treated as finalized. Functional motion should be subcontracted by function; maintenance should be carried out at each code level in accordance with the determination rules specified in Section 2.4.2. When selecting components, the integrator should base its decisions on the current level of the selected code; it is not advisable to make assumptions based solely on the family level.

3.7.4 Explanation Regarding Full Matrix Filling

All three encoding tables are full-coverage matrices (8×3=24 or 7×3=21); however,

this does not mean that every combination has a corresponding physical module. In practical engineering applications, certain combinations of transmission methods and size ranges may simply not exist—for example, "vertical roller shutter + small size range" may be impractical in engineering practice.

In the matrix, combinations that are not actually valid should be marked with "—" or "N/A" to avoid incorrect selection; the applicable combinations are subject to the availability of coding and the ability to produce the drawings.

3.7.5 The Value of Maturity Indicators for Integrators

The core value of maturity indicators lies in managing front-end expectations:

● Solidified modules: Once selected, they can proceed directly to BOM preparation and procurement, with a controllable cycle.

◐ Parametrizable adjustment module: After component selection, parameter verification and localized design modifications are required; the associated cycle must be evaluated separately.

○ Module redesign required: This is equivalent to traditional customization; the timeline and cost must be assessed separately.

Clearly specifying the proportions of the three types of modules in the project quotation and delivery commitment can prevent delivery delays caused by underestimating the workload for customization.

3.8 Three-Action Linked Sequence and State Machine

3.8.1 One-Click Pre-Takeoff: Temporal Empirical Analysis

HEISHA API defines a comprehensive pre_takeoff (one-click takeoff preparation) command, whose step_key sequence is as follows:

check_rainfall → confirm_rainfall → check_wind → confirm_wind →

close_putter → turn_on_rc → open_cover → open_drone → free_putter →

check_pilot → check_battery → confirm_battery → check_gps → confirm_gps →

check_rtk → confirm_rtk

Progress reporting structure: output.status (canceled/failed/in_progress/ok/paused/rejected/sent/timeout), output.progress.percent (0−100), and output.progress.step_key. Completion 判定 = percent = 100 AND status = ok.

3.8.2 Chronological Segmentation Interpretation

The following interpretation is based on the name of step_key and the engineering logic; it is not factual.

Previous section: Environmental access control (check_rainfall → confirm_wind)

The first four steps of the sequence are environmental checks: first, check rainfall (check_rainfall); if it exceeds the threshold, proceed to confirm_rainfall and await manual confirmation; then, check wind speed (check_wind); if it exceeds the threshold, proceed to confirm_wind and await manual confirmation.

The environmental inspection is performed before any mechanical operation, embodying the safety design principle that "environmental access control precedes mechanical action." If it is discovered after the hatch has been opened that wind or precipitation levels exceed the permissible limits, not only will the drone be unable to take off safely, but the equipment inside the cabin may also be damaged. The presence of the confirm_xxx step indicates that the system supports a "human-in-the-loop" approach: when an exceedance is detected, the system does not immediately reject the operation; instead, it suspends it pending operator confirmation, thereby balancing safety and flexibility.

Middle section: transmission sequence (close_putter → free_putter)

This is the core section of the three coordinated actions; the execution sequence is as follows:

1. close_putter (retract the charging pusher/tighten the charging lever): First retract the charging pusher to prevent spatial interference between the pusher and the cabin door when the cover is opened subsequently.

2. turn_on_rc (turn on the remote control): Start the drone remote control and establish the remote-control link.

3. open_cover (open the hatch/cover): Open the hatch to expose the drone.

4. open_drone (start the drone): Power on the drone.

5. free_putter (release the pusher/unlock the charging lever): releases the centering/pusher mechanism, allowing the drone to take off.

The inevitability of this sequence can be understood from the perspective of interlock safety:

Why should the push rod be retracted before opening the lid? When the push rod (charging rod) is in the retracted position, it is located beneath or beside the drone; if the lid is opened before the push rod has been retracted, the push rod may interfere with the door's motion path, causing the door to become stuck or resulting in damage to the push rod.

Why should the remote control be activated before opening the lid? Activating the remote requires time for system boot and link establishment; initiating it in advance can reduce the waiting time after the cabin door opens and shorten the period during which the drone is exposed to the external environment.

Why should the pusher rod be released before powering on the drone? After the drone is powered on, it must complete self-diagnosis and positioning initialization; at this stage, the pusher rod remains locked, providing the drone with a stable physical reference. If the pusher rod is released before powering on, the drone may lose its positioning constraints before initialization is complete, resulting in drift.

Why is the pusher released at the end? Releasing the pusher is the final release of the physical constraint that prevents the drone from taking off; it can only be performed once all prerequisite conditions have been met (the door is open and the drone is ready).

The above interlock conditions can be summarized according to their action dependencies as follows: the door status is a prerequisite for the maneuvering action; reaching the center position is a prerequisite for the charging contact; and environmental access control is a prerequisite for the entire chain. The complete thresholds (positioning 判定 time, number of timeout retry attempts, and failure rollback state) are configured by the T100 local program according to the module type.

Post-flight: Pre-flight self-check (check_pilot → confirm_rtk)

Once the transmission sequence has completed, the system proceeds to the pre-flight self-check: verify the Pilot's online status, battery level (if below the threshold, confirm_battery will wait for confirmation), GPS signal, and RTK signal.

Self-checking is performed after the transmission sequence because only after the

drone has been powered on and the pushrod has been released can the actual battery status, GPS/RTK signal, and other information be obtained. If these items are checked before the lid is opened, the results may be invalid because the drone has not yet been powered on.

3.8.3 The paired semantic relationship between check_xxx and confirm_xxx

check_xxx and confirm_xxx form an interaction pattern of "automatic inspection + manual confirmation":

check_xxx: The system automatically detects a specific metric.

If the indicator is normal: skip the corresponding confirm_xxx and proceed to the next step.

If an indicator is abnormal, the system enters confirm_xxx and suspends itself while awaiting the operator to send a confirmation command via the API. The operator can choose either "Continue Execution" or "Cancel Task."

This design prevents the system from automatically executing operations that may pose risks under abnormal conditions; it also avoids the rigid behavior of directly rejecting tasks due to transient anomalies, such as brief GPS signal obstruction.

3.8.4 Reverse process: One-click charging (after_landing)

The step_key sequence for after_landing (one-click charging) is:

close_putter → close_drone → close_cover → start_charge → turn_off_rc

This is a reverse-order operation for one-touch flight preparation (not fully symmetrical):

1. close_putter (retract the charging rod): First retract the push rod to prepare for closing the cover.

2. close_drone (turn off the drone): Power off the drone.

3. close_cover (close the rain cover): Close the hatch to restore the seal.

4. start_charge (start charging): initiate the charging process.

5. turn_off_rc (turn off remote): Turns off the remote to save battery power.

Note: One-touch charging does not include an environmental inspection phase because the drone has already landed and the hatch is about to close; under these

conditions, environmental factors no longer affect operational safety. Charging should be carried out after the hatch has been closed, ensuring that the interior environment remains controlled throughout the charging process.

3.8.5 State Enumeration and Exception Handling

The state enumeration for each transmission module defines an abnormal state:

module	anomalous mode	Unknown state
cover_state (D series)	3=Abnormal	9=Unknown
putter_state (D series)	3=Abnormal	9=Unknown
expansion cylinder	0x06=FAULT	0x00=UNKNOWN
Return rod	0x06=FAULT	0x00=UNKNOWN
hatchway_state	6 = Fault	0=Unknown
pulp_motor_state	6=Incorrect	0=Unknown

Distinguishing between the anomalous state and the unknown state is meaningful:

Abnormality/Fault (FAULT): The module has detected a clear fault condition (e.g., motor overcurrent, limit timeout, or communication interruption), requiring manual intervention or a reset.

UNKNOWN: During module power-on initialization or when communication is temporarily interrupted, the status has not yet been determined. The UNKNOWN state does not necessarily indicate a fault; the system may return to a normal state once communication is restored or initialization is completed.

This distinction prevents the system from falsely reporting faults during transient communication interruptions, while also ensuring that genuine faults are not overlooked.

3.8.6 Continuing the Run Despite Network Interruptions: A Reliability Design for Local Execution

The API documentation explicitly states: "A C-language program using the integrated instruction set runs on the T100 control board located locally in the machine room. Its advantage is that, when processing batch instructions, it can operate without being affected by network instability; even when the network is disconnected, it can continue executing all instructions."

This design is critical to the reliability of the actuation layer. Integrated commands such as one-touch takeoff/one-touch charging involve multiple sequential actuation actions, and the entire process may take several minutes. If the actuation sequence relies on cloud-based continuity, network jitter or disconnections may cause the process to

interrupt midway — for example, when the door has opened but the drone has not yet started — leaving the device in an unsafe state. Local execution on the T100 ensures atomicity of the actuation sequence: once initiated, the process will continue until completion or until a local failure occurs, regardless of network conditions.

3.8.7 Figure 3-15: One-Click Pre-flight Three-Motion Linkage Timing Diagram

```
sequenceDiagram
Participant: Cloud as cloud operator
Participant T100 as the T100 local control board
Participant: Env as an environmental sensor
Participant: Door as a door actuation module
Participant Center as a mobile module (centering/push rod)
Participant: Drone as UAV/remote controller

Cloud->>T100: pre_takeoff(check_rainfall=true, check_wind=true)

Notes on T100; Env: Front end: Environmental Access Control
T100->>Env: Check rainfall
Alt: Rainfall exceeds the standard
T100-->>Cloud: confirm_rainfall (awaiting confirmation)
Cloud->>T100: Confirm Continue
end
T100->>Env: Check wind speed
Alt wind speed exceeds the limit
T100-->>Cloud: confirm_wind (awaiting confirmation)
Cloud->>T100: Confirm Continue
end

Notes on the T100 Drone: Mid-section: Drive sequence
T100->>Center: close_putter (close the putter)
```

Center-->>T100: Pusher retracted

T100->>Drone: turn_on_rc (turn on the remote control)

Drone-->>T100: Remote control activated

T100->>Door: open_cover (hood)

Door-->>T100: Hood opened

T100->>Drone: open_drone (Open Drone)

Drone-->>T100: Drone has been activated

T100->>Center: free_putter (release the putter)

Center-->>T100: Pusher released

Notes on the T100 Drone: Post-flight: Pre-flight self-check

T100->>Drone: check_pilot

T100->>Drone: check_battery

T100->>Drone: check_gps

T100->>Drone: check_rtk

T100-->>Cloud: status=ok, percent=100

Figure 3-15: One-Click Pre-flight Three-Motion Linkage Timing Diagram

3.8.8 Figure 3-16 Transmission Module State Machine

stateDiagram-v2

state "cover state (cover_state)" as CoverState {

[*] --> Closed: Power-on initialization

Closed --> Opening: open_cover

Opening--> Opened: Completed

Opening--> Fault: Timeout/Overcurrent

Opened --> Closing: close_cover

Closing--> Closed: Completed

Closing--> Fault: Timeout/Overcurrent

Closed--> HalfOpen: Manual/Exception

Opened--> HalfOpen: Manual/Exception

Fault--> Closed: Reset

Unknown--> Closed: Communication restored

Unknown--> Fault: Diagnosis confirmed

}

state "return-to-center state" as CenterState {

[*] --> Unlocked: Power-on initialization

Unlocked--> LockingStep1: Centering and Tightening

LockingStep1--> LockingStep2: Step 1 completed

LockingStep2--> Locked: Step 2 completed

Locked--> Unlocking: Return to Centered State and Release

Unlocking--> Unlocked: Unlocked

LockingStep1--> Fault: Abnormal resistance

LockingStep2--> Fault: Abnormal resistance

Unlocking--> Fault: Timeout

Fault--> Unlocked: Status reset

}

state "Drum state" as DrumState {

[*] --> DrClosed: Power-on initialization

DrClosed--> DrOpening: Open the rain cover

DrOpening--> DrOpened: Set (Bit0)

DrOpened--> DrClosing: Close the rain cover

DrClosing--> DrClosed: In place (Bit1)

DrOpening--> DrFault: Timeout

DrClosing--> DrFault: Timeout

DrFault--> DrClosed: MCU reset

}

Figure 3-16 Transmission Module State Machine (Based on Physical Model State Enumeration)

The trigger conditions for state transitions are defined in three stages: "instruction issuance — execution feedback — position confirmation"; the timeout threshold is configured according to the module type and stroke length. The figure above illustrates the logical relationships between states; in engineering implementation, the timeout and retry parameters shall be governed by the T100 program parameter table.

3.9 Customizable Boundaries: What Can Be Modified and What Cannot

3.9.1 Three product boundaries

The product scope of HEISHA is clearly defined as follows:

1. No turnkey solutions provided: only the hangar platform itself is offered, with supporting services provided to solution providers.

2. Not building drones or robots: only "building houses for robots."

3. Do not develop cloud-based business software: provide open hardware interfaces, enabling customers to develop their own cloud-based scheduling platforms.

These three boundaries determine the scope of customization for the transmission layer.

3.9.2 Customizable items

Based on the key customization considerations for each product specification and FAQ, the following items can be customized within the transmission layer:

Customization Dimensions	concrete content	according to
size	The open and closed dimensions can be adjusted as needed.	FAQ: Key Considerations for Customization – Category 1
Opening method	Eight door operation modes are available; lift function is optional.	FAQ: Key Considerations for Customization – Category 2
Return-to-center method	Gravity centering or pushrod centering	FAQ: Key Considerations for Customization – Category 2
configuration design	The hull shape can be designed as required.	FAQ: Key Considerations for

Customization Dimensions	concrete content	according to
		Customization – Category 2
T3 combined/separated	The monitoring post may be integrated with or separated from the main structure of the hangar.	FAQ: Key Considerations for Customization – Category 2
Vehicle-mounted shock absorption	Vehicular applications require consideration of vibration isolation design.	FAQ: Key Considerations for Customization – Category 2
Deployment method	Forklift/Crane/Wheels/Aluminum alloy base	FAQ: Key Considerations for Customization – Category 2
peripheral interface	Emergency stop buttons, etc.	FAQ: Key Considerations for Customization – Category 2
material quality	Aluminum alloy / carbon fiber / stainless steel / galvanized sheet / glass-fiber composite materials, etc.	Product Specifications
surface	Colors, logo printing, warning signs	D80/D135/D200 Customization Options
Enhanced Protection	Salt spray protection, higher IP rating, explosion-proof version	D65/D80 Customization Options
Optional features	Photovoltaics/Energy Storage/Satellite Communications/Edge Computing/Lightning Protection/Automatic Battery Swapping	D90/D200 optional add-on configurations

3.9.3 Non-customizable / Items requiring third-party coordination

project	explain	according to
Drones-side retrofitting	HEISHA cannot facilitate structural modifications on the UAV side (e.g., installation of a wireless charging receiver).	FAQ: Wireless Charging Q&A
Cloud-based business software	HEISHA provides an open interface, but the cloud-based scheduling platform is developed independently by the customer.	D90 System Topology Description
Communication Method Module	The communication method module is provided by the customer, while Heisha is responsible for its integration.	D90 System Topology Description

3.9.4 Impact of changes on cycle time and cost

The impact of changes on cycle time and cost shall be assessed using the four-level framework set out in Section 2.5.4: Levels I and II primarily involve configuration and drawing revisions; Level III requires verification of individual modules; and Level IV requires verification of the complete machine structure. Quotations and delivery schedules shall be determined accordingly by tier, and the level of change shall be specified to the customer.

Type of modification	Impact on the cycle	Impact on costs
Select ● Cured Module	Minimum (direct call)	Minimum (bulk procurement)
Select ◐ for parameterizable adjustment module	Intermediate (parameter confirmation and local modifications required)	Medium (partial non-standard components)

Type of modification	Impact on the cycle	Impact on costs
Select ○ : The module requires redesign	Maximum (full design – prototyping – validation cycle)	Maximum (fully non-standardized)
New active functions	Relatively large (may require the development of a new module)	Relatively high (R&D allocation)
Enhanced Environmental Adaptability	Medium (sealing/temperature control/anti-corrosion process adjustments)	Medium (material and process changes)

3.10 Example of a Typical Module Combination

This configuration sheet is based on product form and description, using module codes to express the customization solution. The code values serve as illustrative configurations; the specific project shall be subject to the configuration sheet issued by Heisha. The value of this section lies in demonstrating the approach of "describing a solution through codes."

Example 1: Small vehicle-mounted inspection aircraft (DCAP MINI class)

Module Category	Inference encoding	Basis for inference
Door movement	MD06 (Single-Open Smooth · Small)	DCAP MINI: Opened dimensions: 1360 × 1480 × 280 mm; width increased by 730 mm; likely a single-side sliding mechanism.
motor-driven	JD23 (Gravity Centering · Small)	For small vehicle applications, lightweight design takes priority; the D007 has demonstrated that gravity-based centering is effective for portable use cases.
active	not have	Only charging; no need for battery swapping or product exchange

In this configuration, the door operates via a single-opening rotation mechanism (MD15, low setting) and returns to its gravity-centered position via a mobility mechanism (JD24, low setting); this is consistent with the roof mounting method used in the DCAP MINI.

Example 2: Medium-sized ground-based inspection aircraft hangar (Category D80)

Module Category	Inference encoding	Basis for inference
Door movement	MD11 (Drum · Medium)	The D80 packaging list explicitly includes drum signal cable and RJ45 Ethernet plug cable.
motor-driven	JD02 (Return to Center · Center)	The D80 is compatible with M3E/M4E and requires centering for charging.
active	not have	Charging only

The D80 is equipped with a drum door mechanism (MD11, mid-range), as evidenced by the packaging inventory; it is configured according to JD02 (mid-range).

Example 3: Ultra-cold, ultra-dusty, heavy-load hangar (Class D90)

Module Category	Inference encoding	Basis for inference

Module Category	Inference encoding	Basis for inference
Door movement	MD01 (Double-Open Smooth · Large) Or custom multi-stage sealing	The "D90 Description" for the "multi-stage door sealing structure" may refer to a customized double-opening smooth variant.
motor-driven	JD01 (Centered · Large) + JD10 (Adjustable Height · Large)	Clearly specify the "integrated landing apron and lifting system."
active	ND01 (3-axis battery swap · Large) (Optional)	The optional expansion configuration for the D90 includes a "drone automatic battery-swapping module."

The centering and lifting functions of the D90 correspond to JD02 and JD11, respectively; the door actuation is configured for lifting and rotation (MD17, mid-range), enabling IP65 sealing and high-frequency opening and closing.

Example 4: Vertical Logistics Hangar (Class D330/V200)

Module Category	Inference encoding	Basis for inference
Door movement	MD22 (Vertical Roller Shade · Large)	Container-style design with a large opening; vertical roller shutters are suitable for large openings.
motor-driven	JD14 (Horizontal Rotation · Medium)? + JD01 (Centering · Large)	When referring to "head-direction calibration and centering," horizontal rotation is used to adjust the orientation of the head.
active	ND04 (three-axis replacement · large) Or ND10 (lifting replacement · large)	Logistics scenarios may require a product exchange feature.

The head-direction calibration for D330/V200 corresponds to JD14 (horizontal rotation, medium setting); the door mechanism is configured as a vertical roller shutter (MD23, high setting) to accommodate longitudinal storage in container configurations.

Example 5: Portable Luggage Carry-on (Class D007)

Module Category	Inference encoding	Basis for inference
Door movement	MD06 (Single-Open Smooth · Small)	The suitcase has a compact size and features smooth single-opening functionality, making it ideal for use.
motor-driven	JD23 (Gravity Centering · Small)	Clearly define the "completely new gravity-based centering design"
active	not have	Charging only

The gravity centering of D007 corresponds to JD24 (small setting); the door mechanism is configured for smooth single-opening operation (MD06, small setting), and when stored, it conforms to the exterior shape of a rolling suitcase.

3.11 Transmission Layer Selection Checklist

3.11.1 Model Selection Decision Matrix

Based on the key considerations for customizing the FAQ-based Category 2 and Three-Motion Module System, the following selection decision matrix has been compiled:

demand characteristics	Recommended door operation mode	Recommended mobility mode	Is it necessary to be active?	remarks
Small drones (≤ 2 kg), vehicle-mounted/portable	Single open smooth (small)/drum (small)	Gravity Re-centering (Small)	deny	Weight reduction first
Medium-sized UAVs (2−8 kg), ground-based inspection	Double smooth (medium) / Drum (medium)	Return to the center (center)	deny	standard layout
Large unmanned aerial vehicles (>8 kg), heavy-load protection	Double smooth (large)/lift smooth (large)	Return to Center (Large) + Rise/Descend (Large)	selectable	Multi-stage sealing
Downward-fixed-wing aircraft	Vertical roller shutter (large)/Lift-and-rotate (large)	Horizontal rotation + centering	Exchange available	Nozzle calibration required
High-frequency operation, short intervals	Select as needed	Return to the center	Three-axis battery swap / robotic arm battery swap	Fast battery swapping
logistics	Select as needed	Return to center + translation	Three-axis exchange / vertical exchange	multistation
Hydrogen-powered drones	Select as needed	Return to the center	Three-axis hydrogenation	safe guarding
Agriculture/Firefighting	Select as needed	Return to the center	Water addition mechanism	Liquid piping sealing
Multi-machine storage	Select as needed	Vertical magazine/rotating magazine	as required	Space utilization
Extreme Cold and Extreme Dust	Custom multi-stage sealing	Return to Center + Rise and Fall	selectable	IP65, Teflon sealing
In-car embedded	Single open smooth (small)/drum (small)	Gravity Re-centering (Small)	deny	aseismatic design

The recommendations in the table above are based on institutional principles and product validation and constitute selection guidance; the final configuration must be determined in conjunction with the equipment model parameters, deployment environment, and functional requirements, and confirmed by a configuration document issued by Heisha.

3.11.2 Recommended Selection Process

1. Determine the drone's parameters: model, wheelbase, takeoff weight, leg configuration, and charging port location.

2. Define the deployment environment: temperature range, humidity, salt spray, dust,

wind speed, and installation method (ground-mounted/vehicle-mounted/hoisting).

3. Define functional requirements: charging only / battery swapping / product exchange / hydrogen refueling / water refueling / paddle collection.

4. Select the door actuation module: choose from eight options based on the drone's dimensions and deployment space.

5. Select the mobility module: choose from eight options based on the UAV's positioning requirements and the interior layout.

6. Select the active module: Based on functional requirements, choose from one of the seven available options (note the differences in maturity levels).

7. **Confirm the size class: Based on the criteria in 2.3.3, determine the class according to the aircraft type's landing gear outer dimensions and the unfolded blade diameter; for boundary aircraft, verify the class using the net dimensions of the cabin opening.**

8. Generate a configuration list: Use MD/JD/ND coding to express the complete configuration and submit it for HEISHA review.

Appendix 3-A: List of Related Patents (only valid and pending patents are listed)

Authorized invention patent (patent rights maintained)

title of invention	request number	Authorization Publication No.	Authorization Date
An intelligent drone charging station with rapid battery cooling functionality	202210205995X	CN114425958B	2024-04-12
A UAV Propeller Recovery Mechanism System	2022100869473	CN114408157B	2023-12-22

Inventive patent pending for substantive examination (related to structural transmission)

title of invention	request number	Publication No.	Applicant
A fully openable and closable drone storage system	2025100274387	CN119737081A	Shenzhen Heisha Technology Co., Ltd.
A drone hangar with drone homing functionality	2024118070337	CN119611847A	Shenzhen Heisha Technology Co., Ltd.
Drone hangars, hangar control systems, and hangar control methods	2025104790318	CN120229407A	Guangdong Xinhui CIMC Special Transport Equipment Co., Ltd., Midum International Marine Container (Group) Co., Ltd., Shenzhen Heisha Technology Co., Ltd.
Drone logistics airport	2024117556935	CN119551243A	Shenzhen Heisha Technology Co., Ltd.

Utility Model Patent (patent right maintained; relates to the transmission structure)

title of invention	Authorization Publication No.	Authorization Date
An airfield for UAV parking	CN222373139U	2025-01-21
A drone storage facility with a roof or hatch that slides open to access the hangar	CN222040789U	2024-11-22
A UAV blade collection device and a helipad	CN222663815U	2025-03-25
An electrode arrangement structure for the centering mechanism of a UAV charging platform	CN210838982U	2020-06-23
A charging platform with a large takeoff and landing area for drones	CN213973614U	2021-08-17
A small-scale UAV fleet suitable for vehicle-mounted deployment and equipped with solar panels	CN222040790U	2024-11-22
A compact, vehicle-mounted drone library	CN221986641U	2024-11-12
A drone storage facility designed for easy replacement of fire extinguishing rounds and stable parking	CN222202949U	2024-12-20
A drone storage facility designed for easy transport and equipped with fire suppression munitions	CN222614939U	2025-03-14
A Portable UAV Battery Management Box	CN222062310U	2024-11-26

Design Patent (Patent Right in Force)

title of invention	Authorization Publication No.	Authorization Date
Drone charging station	CN306768576S	2021-08-20

The table above lists only patents whose patent rights remain in force and whose substantive examination is pending. Patents that have been withdrawn, rejected, or terminated due to overdue annual fees are excluded, so that readers do not mistakenly treat expired patents as valid technical assets.

Charpter 4 L2 Electrical and Energy Layer: Power Supply, Charging, and Energy Storage

4.1 Overview of the Electrical Architecture

The electrical system of the HEISHA processing warehouse provides the complete power path from the external power supply to the power distribution of each functional module. Depending on the product model and deployment scenario, the external power input may come from mains power (AC220V / AC100~240V / three-phase), an on-board DC power supply (DC12V / DC24V), a photovoltaic energy-storage off-grid system, or a diesel generator. Regardless of the input configuration, the warehouse's internal power is distributed through a power distribution unit to the following voltage ranges:

Voltage range	Typical Applications	remarks
AC220V	Compressor air conditioner, PTC heater, energy storage cabinet inverter output	Some models support a wide voltage input range of AC 100–240 V.

Voltage range	Typical Applications	remarks
DC48V	Energy storage cabinet battery pack (48V 100AH)	For off-grid energy storage applications
DC24V	ACK2000 controller power supply, DCAP MINI power supply, and expansion interface	ACK2000 controller power supply range: DC 12–24 V
DC12V	ACK150 power supply, DCAP/DCAP INBUILT main power supply, and vehicle cigarette lighter compatibility	DCAP V1 Screened Boost Module
DC5V	High-current relay trigger (3.3V–5V), USB DC output, and sensor power supply	The D200 solar panel provides two USB DC 5V outputs.

Power Flow Architecture

The following text describes the typical power-flow path in the HEISHA crusher plant (corresponding to Figure 4-1):

External power input

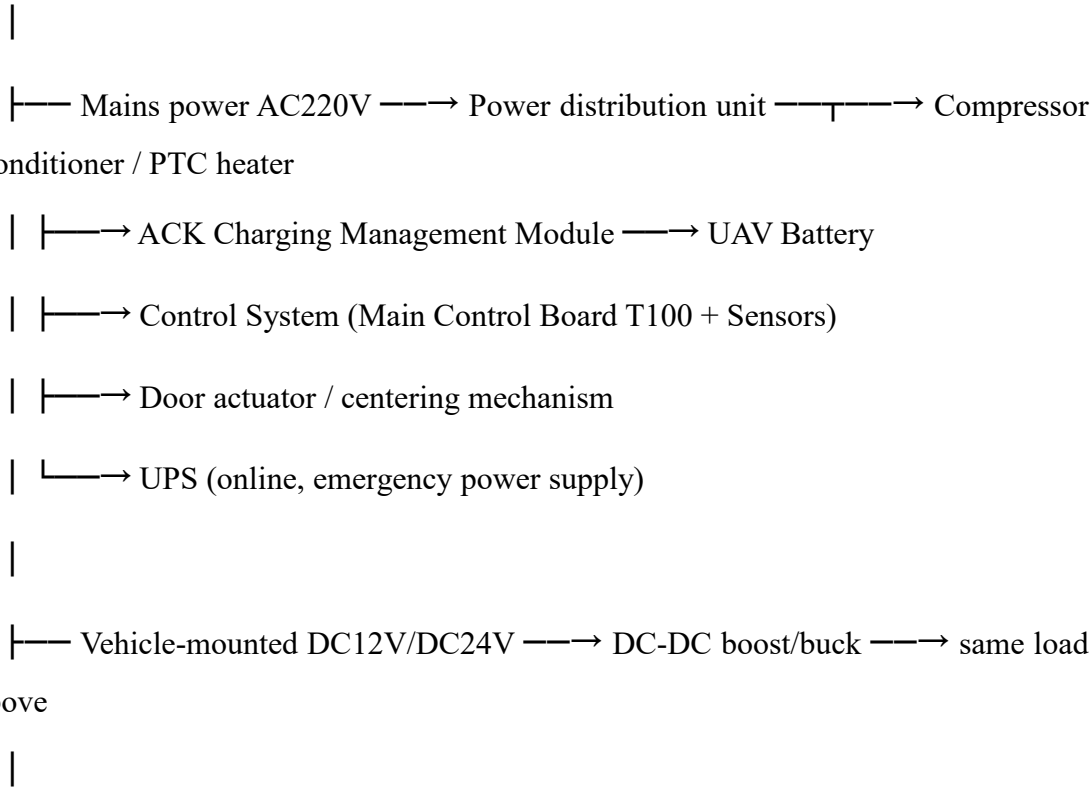


Figure 4-1 Typical power-flow architecture of a HEISHA machine warehouse (text version)

From an engineering perspective, the core design considerations of the

aforementioned architecture lie in voltage conversion efficiency and the allocation of power margin across different power-supply scenarios. In the utility-power scenario, air conditioners and charging modules are the two primary power consumers; in the in-vehicle scenario, given the constraint on DC12V/DC24V input power (typically ≤120W), standby power consumption must be strictly controlled, and functional modules must be selected through trade-offs; in off-grid scenarios, the inverter efficiency of the energy-storage cabinet and the battery capacity directly determine the operating duration.

Extended Interface

Models such as the D80, D135, and D200 feature an RS485 expansion interface as well as 24 V, 12 V, and 5 V power supply expansion ports, enabling integrators to connect custom sensors or devices externally. DCAP models also provide an RS485 expansion interface. These expansion interfaces give the hangar electrical system the capability to supply power to and communicate with third-party equipment; however, integrators should take into account the impact of the expanded load on the overall power budget of the system.

4.2 Charging system

4.2.1 Charging Methods and Technical Roadmaps

The HEISHA Drone Studio employs contact charging as its primary charging solution. Its charging electrodes feature gold-plated surfaces, and the mount types include a non-destructive clip mount (e.g., the D80, compatible with the Mavic 3E/T and Matrice 4E/T) and a non-destructive installation mount (e.g., the D135, compatible with the Matrice 350 RTK).

The Three Key Elements of Charging Protection:

The charging circuit of all models includes the following three basic protections:

1. Anti-backflow protection: prevents the drone battery from discharging back into the charging circuit, thereby avoiding damage to the charging module and control circuitry.

2. Over-discharge protection: Monitor battery voltage to prevent cell damage caused by over-discharge.

3. Temperature monitoring: Real-time monitoring of battery temperature; charging automatically stops when the temperature exceeds the safety window.

Coupling relationship between automatic alignment, contact charging, and the centering mechanism:

From an engineering perspective, the reliability of contact charging depends heavily on landing alignment accuracy. The charging electrode must be precisely aligned with the battery terminal contacts after the UAV has landed and aligned; only then can a stable electrical connection be established. This means that:

The positioning accuracy of the charging station directly determines the charging success rate;

The centering method (gravity centering vs. pushrod centering) affects alignment consistency;

The design of the charging stand must be compatible with the centering travel to avoid poor contact caused by mechanical tolerances;

In the key considerations for customizing the FAQ, "contact charging stability (centering drive)" and "compatibility (centering)" are listed as core evaluation items for charging management, indicating that these are critical aspects that require repeated verification in practical engineering applications.

It is recommended that system integrators, when selecting equipment, evaluate the centralization unit and charging system as a single integrated unit rather than selecting them independently.

4.2.2 ACK Charging Management Module Series

The ACK series is a proprietary charging management module developed by HEISHA, designed to meet the charging needs of everything from small consumer-grade drones to large industrial drones. The following is a comparison of three products:

Parameter items	ACK150	ACK800	ACK2000
Compatible devices	M3E/T 、 M4E/T (3S/4S)	M300 (TB60 battery)	M400 (TB100C battery)
Power supply input	DC18-24V	AC180-240V 50Hz	Charging input: 54.6 V; controller: DC 12–24 V
output power	130W	800W	3000W
Charging compatibility	3S/4S adaptive	6S – 12S compatible adaptive charging	Dedicated TB100C
Control signal/protocol	CAN highway	—	TTL / MODBUS RTU
size	17.5×4.7×2.6cm	253×198×750mm	—
weight	128g	2.3kg	0.534kg

Parameter items	ACK150	ACK800	ACK2000
Shell material	—	—	Aluminum alloy die-casting (surface anodizing treatment for corrosion resistance)
Heat dissipation method	—	—	natural heat dissipation
levels of protection	—	—	IP54
working temperature	—	—	-10 °C to 45 °C (charging); -20 °C to 60 °C (standby)
BMS communication	—	—	Supports communication with the built-in BMS of the TB100 battery

ACK150 and ACK800 are low-power charging modules; existing documentation primarily provides their selection parameters. ACK2000 has the most comprehensive parameters and can serve as a representative example of charging-module design specifications. For the "—" entries in the table, the module datasheet shall prevail.

ACK2000 Detailed Specifications Sheet

ACK2000 is a charging management module specifically developed for the DJI M400 drone; it enables independent charging of a single-channel TB100C battery. It can be used as an internal charging management module in a drone hangar or operated independently as a standalone charger.

Electrical performance parameters:

Parameter	Price
Controller supply voltage	DC12~24V
Charging input voltage	54.6V
Maximum charging input current	40A

Physics and structural parameters:

parameter	price
weight	0.534kg
Shell material	Aluminum alloy die-cast housing (surface anodized for corrosion resistance)
Heat dissipation method	natural heat dissipation
Interface method	TTL
Agreement Format	MODBUS RTU
AC input	IEC 60320 C14 standard plug (with anti-detachment latch)
Battery output	Dedicated TB100C battery interface (compatible with DJI's original interface; includes data communication pins)
size	—

parameter	price

(The original image accompanying the material, image62.png, was not embedded with the text; the original can be requested from Heisha.)

Figure 4-2 ACK2000 dimensional diagram

Environmental adaptability parameters:

parameter	price
Operating temperature (charging state)	-10℃ ~ 45℃
Operating temperature (standby mode)	-20℃ ~ 60℃
Storage temperature	-40℃ ~ 85℃
relative humidity	5% ~ 95% (no condensation)
levels of protection	IP54 (dust and water splash protection; suitable for outdoor use in environments without heavy rainfall)
Altitude acclimatization	≤3000 m (exceeding this limit requires derating; power decreases by 10% for every 1000 m increase in altitude)

Safety and protection features:

Protection type	Thresholds and Timing
Overvoltage Protection (OVP)	Input voltage> 54.9 V: charging restricted
undervoltage protection	Input voltage <54.3 V: charging is restricted
Overcurrent Protection (OCP)	If the charging current exceeds 40 A, current limiting will be activated; power will be cut off after 3s of continuous operation.
Battery temperature protection	When the battery temperature is <0 °C or>45 °C, charging automatically stops and a notification is displayed.
BMS Communication Coordination	Supports communication with the built-in BMS of the TB100 battery to obtain real-time data on battery capacity, temperature, and cycle count.
Battery Fault Protection	When cell damage or communication abnormalities occur, immediately terminate charging and trigger an alarm.

Two modes of use:

1. When used as a standalone charger: the ACK2000 must be configured for mode; this can be configured by the user or configured by the manufacturer during factory setup.

2. For use as an onboard charging module in a hangar: users must design the connection between the hangar charging electrode and the aircraft's charging electrode themselves, or arrange for a manufacturer to provide the necessary adapter. The intended mode of use must be specified at the time of factory delivery; the operating mode of the ACK2000 module is configured by the manufacturer.

(The original image accompanying the material, image60.png, was not embedded with the text; the original can be requested from Heisha.)

Figure 4-3: Usage of the ACK2000 single charger

(The original image accompanying the material, image61.png, was not embedded with the text; the original can be requested from Heisha.)

Figure 4-4: Usage of the internal charging module in the ACK2000 hangar

Altitude derating note:

The maximum altitude for altitude adaptation of the ACK2000 is 3,000 m. Beyond this altitude, power decreases by 10% for every additional 1,000 m of elevation. This means that at an altitude of 4,000 m, the available power is approximately 90% of the rated value; at 5,000 m, it is approximately 81%. For high-altitude deployment projects, such as those on the Qinghai – Tibet Plateau or in the Andes Mountains, it is recommended that an appropriate margin be reserved in the power budget.

The high-altitude adaptability of the complete aircraft system is jointly determined by three factors: the derating curve of the charging module (ACK2000: power decreases by 10% for every 1,000 m of altitude increase), the cooling degradation of the air-conditioning compressor under low ambient pressure, and the sealing performance of the seals under low ambient pressure. For high-altitude deployment, these factors should be verified item by item, and power redundancy should be configured according to the available correction capability.

3. The Engineering Significance of S-12S / 2–18S Adaptive Charging

The ACK800 supports 6S–12S compatible adaptive charging, and its high-current charging output relay is compatible with 2S – 18S lithium-ion drone batteries. The engineering significance of this wide-range adaptive design lies in the following:

Reduce the number of SKUs: a single charging module can be compatible with multiple battery specifications, thereby reducing the complexity of spare-parts management;

Multi-model compatibility: System integrators can switch between different UAV

models on the same aircraft platform without replacing the charging module;

Simplify on-site commissioning: adaptive charging eliminates the need for manual configuration of the series count, thereby reducing the risk of human configuration errors.

However, it should be noted that the prerequisite for adaptive charging is that the charging module must be able to correctly identify the number of battery cells in series and the battery chemistry. ACK2000 achieves this identification through communication with the built-in BMS of TB100 batteries, whereas general-purpose modules may rely on voltage detection or manual DIP switching. Integrators are advised to verify, when selecting a module, whether the battery communication protocol of the target model is compatible with the charging module.

4.2.3 High-current charging output relay

The high-current charging output relay is a self-developed component manufactured by Heisha, used for switching control and anti-backflow protection in the charging circuit.

technical parameter:

parameter	price
Compatibility Scope	2−18s lithium-ion battery UAV
characteristic	Anti-backflow; normally open; external 3.3 V−5 V trigger; low internal resistance and low voltage drop
working voltage	DC 0-80V
rated current	50A
size	44 mm (length) × 34 mm (width)
weight	99g
working temperature	-30 to +40 °C
Working humidity	0%~80%

Key selection criteria:

This relay is normally open and requires an external 3.3 V−5 V signal to trigger its closure; it is suitable for direct driving by an MCU/GPIO.

Low internal resistance and low voltage drop characteristics help reduce losses in the charging circuit, which is particularly important for high-current charging scenarios;

The anti-backflow function serves as the fundamental safety safeguard for contact charging, preventing the drone battery from discharging in reverse when the charging connection is disconnected;

The lower operating temperature of − 30 ° C is sufficient for most outdoor

applications; however, in extremely cold environments (e.g., D90 rated at −40 °C), the low-temperature reliability of the relay must be verified.

4.2.4 Drone modification components

Heisha provides the following drone-side modification components for interfacing drones with aircraft hangar charging systems:

Charging stand:

DJI M350 Charging Tripod

DJI MAVIC3 E/T and M4 E/T charging tripod

Other aftermarket parts:

Remote control board

Remote control base

Battery modification / switching board

The aforementioned modification components (charging stand, battery switching board, remote-control control board, and base) are all interface components customized according to the specific device model; their specifications are determined in conjunction with the model and charging solution, and the interface specification sheet issued by HEISHA shall prevail during component selection.

4.2.5 The Feasibility Threshold of Wireless Charging

Regarding wireless charging, Heisha's position and technical boundaries are as follows (the FAQ has been transcribed verbatim):

We can provide a drone hangar that matches the customization requirements, install the charging and transmission unit beneath the centering board, provide standard power supply, and incorporate temperature control to enable charging.

However, it is not possible to provide assistance with modifications to the drone itself; this work can only be carried out by the drone manufacturer. Reasons: 1. Wireless-charging drones require extensive structural modifications — for example, the battery must be positioned at the bottom to serve as the landing surface, thereby shortening the effective charging distance. 2. No payload may be mounted beneath the battery; existing payloads must be relocated through a separate design. 3. If the original drone is equipped with a obstacle-avoidance camera or an infrared distance sensor beneath it, these

components must be adjusted; such changes constitute a major structural modification to the drone. 4. The radio frequency circuitry should ideally be integrated into the battery; if this is not feasible, it should be placed as close as possible to the bottom of the battery. 5. The weight and efficiency of the wireless charging coil must be adjusted by the drone manufacturer based on the aircraft's payload capacity, power requirements, and flight-control specifications.

Once the drone manufacturer has completed the customized wireless charging retrofit, Heisha can provide a matching hangar to enable remote wireless charging.

From an engineering perspective, this boundary statement reflects HEISHA's product positioning: "HEISHA provides only aircraft-hangar platforms; it does not manufacture drones." Wireless charging system integration involves structural modifications to the drone's airframe — including battery layout, reconfiguration of payload capacity, adjustment of obstacle-avoidance sensors, and coil integration. These changes directly impact flight safety and airworthiness and must be carried out by the drone's original manufacturer or by a modification provider with the requisite airworthiness certification. HEISHA's role is to provide hardware support on the hangar side — specifically the installation position for the transmitter unit beneath the central board, power supply, and temperature control — thereby ensuring interface compatibility between the hangar side and the drone side.

4.3 Power Supply and Energy Storage

4.3.1 Power Supply Solution Matrix

The HEISHA Mining Equipment Warehouse supports multiple power supply configurations and is suitable for a variety of application scenarios:

Power Supply Plan	input specification	Compatible models (example)	applicable scene	Selection criteria
Mains power (single-phase)	AC220V ± 15%~ ± 20% 50Hz/60Hz	D65 、 D80 、 D135、D200、D90	Fixed deployment in areas with grid coverage	The most stable and power-rich option; prioritize this choice.
Mains power (wide voltage range)	AC100~240V	D200 、 D100 、 DCAP LITE	Overseas deployment; areas with unstable voltage	Wide voltage compatibility reduces the need for transformers
Three-phase mains power	AC220V ± 15% 50Hz/60Hz	D65	High-power demand and industrial power supply environments	D65 explicitly requires three-phase power supply.

Power Supply Plan	input specification	Compatible models (example)	applicable scene	Selection criteria
Vehicle DC12V	DC12V	DCAP、DCAP V1	Vehicle-mounted mobile inspection	Due to limitations in the vehicle's power supply capacity, power consumption must be strictly controlled.
Vehicle DC 24V	DC24V	DCAP MINI 、DCAP INBUILT	Equipped on special-purpose vehicles and commercial vehicles	The power margin of a 24V system is superior to that of a 12V system.
Off-grid photovoltaic energy storage	Energy storage cabinet / photovoltaic panel	D90, D200 (optional)	Remote wilderness areas with no power grid coverage	The ratio of daily sunlight duration to load power consumption must be calculated.
Diesel generator compatibility	AC220V	D90 (optional)	Extremely remote and long-term off-grid	Fuel refueling cycles and noise levels must be taken into consideration.

matters need attention:

D65 explicitly requires "three-phase mains power supply"; unlike other models that use single-phase AC220V, the on-site power supply conditions must be verified during model selection;

The D90 offers three optional power supply configurations: "grid power / photovoltaic energy storage off-grid system / diesel power supply compatibility," reflecting its positioning for extreme field environments;

In vehicle applications, the notes for DCAP V1 state: "12V (with a screen boost module), remote control & drone synchronous charging & 1 fan," indicating that the 12V input must be boosted by the boost module to meet the internal load requirements, which introduces additional conversion losses.

4.3.2 HEISHA Energy Storage Cabinet

The HEISHA Energy Storage Unit is an independent energy storage system designed for off-grid and weak-grid applications, featuring two operating modes: manual mode and UPS mode.

Detailed explanation of the two operating modes:

pattern	operational principle	applicable scene
manual mode	Regardless of whether there is a mains power supply, all power delivered to the equipment side comes from the inverter output, ensuring voltage regulation.	Areas with poor power-grid quality and significant voltage fluctuations; precision equipment requiring a pure sinusoidal output
UPS pattern	Switch the device to automatic mode; when mains power is available, it will provide direct mains power output.	Scenarios where the mains power is stable but requires power-off protection; balancing efficiency and reliability

From an engineering perspective, the core value of manual mode lies in "ensuring

voltage regulation throughout the entire inverter output process" — even when mains power is present, the output undergoes a complete AC→DC→AC conversion, resulting in superior output waveform quality and voltage stability compared with direct mains power. The trade-off is a loss in conversion efficiency (typically 5%－10%) and the inverter's own power consumption. In UPS mode, the inverter is bypassed when mains power is normal and is switched to inverter output only during a power outage; this mode offers higher efficiency, but the output voltage follows fluctuations in the mains voltage.

Key parameters:

parameter	price
import	AC220V
battery capacity	48V 100AH
UPS mode: utility power output	Voltage = mains voltage; Power ≤ input mains power
Inverter output	Voltage = AC 220 V; power ≤ 4500 W; instantaneous output power = 8000 W
Charging power	0–3600 W, adjustable
Rain protection rating	IP64
Energy storage unit weight	101KG
size	—

(The original image accompanying the material, image64.png, was not embedded with the text; the original can be requested from Heisha.)

Figure 4-5: Exterior appearance and dimensions of the HEISHA energy storage cabinet

Remote monitoring and control capabilities:

The energy storage cabinet supports the following remote functions: -Real-time collection and monitoring of voltage and current at the input; -Remote retrieval and reporting of voltage and current data from the input; -Remote control of power supply activation and deactivation.

These capabilities enable energy storage cabinets to serve as independent remote energy management nodes; integrators can retrieve the energy storage status via APIs and incorporate it into the overall operations and maintenance monitoring system.

4.3.3 UPS and Power Redundancy

built-inUPS:

The D65 comes standard with an online UPS providing a capacity of 650 VA/390 W, enabling emergency operation of connected equipment for ≥ 30 minutes (maintaining core control of the aircraft hangar and keeping the charging module in standby mode when mains power is unavailable). It provides a seamless switch during mains power failure and supports battery low-voltage protection, overcharge and over-discharge protection, and short-circuit protection.

Differences between front-end UPS and rear-end UPS:

Based on the key considerations for customization in Category 5 of the FAQ (Power Supply Management), Heisha classifies UPS systems into two categories:

Back-end UPS: Located at the end of the power distribution chain, it primarily provides short-term emergency power supply to critical loads (control systems, communication modules);

Front-end UPS power supply: Located at the front end of the power distribution chain, it provides voltage regulation, power stabilization, and step-up functionality, thereby conditioning the input power supply for the entire hangar.

From an engineering perspective, the value of a front-end UPS lies not only in providing protection against power outages, but also in stabilizing and regulating the power supply of unstable input sources—such as generator outputs and the ends of long-distance power transmission—thereby protecting downstream equipment from damage caused by voltage fluctuations. A rear-end UPS, by contrast, focuses more on data security, preventing data loss or interruptions in control logic caused by sudden power outages.

D200 optional energy storage power supply:

The D200 may optionally be equipped with a 4.5 kWh voltage-regulated energy storage power supply; its parameters are as follows: -Input voltage: AC 220V-Input power:>=3000VA-Charging power supply voltage: AC 220V, power supply capacity <=2000W; function: power-on/off control and adjustable charging current-Temperature-controlled power supply voltage: AC 220V, power supply capacity <=2000W; function: automatic control

4.3.4 Photovoltaic power supply

D200 solar photovoltaic panel (optional):

parameter	price
capacity	1,000 watt-hours
interiorinput power	1200W
output power	2200W
Interface	Two 220 V AC outlets, two USB DC 5 V ports, and two TYPE-C fast-charging ports with a maximum output of 30 W

D90 Solar Integration:

Solar panels are installed on the top and sides of the D90 enclosure for daytime energy supplementation in field environments without a stable grid power supply. The photovoltaic power output and the capacity of the accompanying battery are configured based on the local solar radiation conditions and the average daily number of operating cycles; these constitute an integral part of the energy storage cabinet selection process (see 4.3.2).

From an engineering perspective, the key to designing a photovoltaic power supply system lies in ensuring that the average daily power generation is ≥ the average daily power consumption multiplied by a safety factor (typically 1.3−1.5). System integrators must perform a comprehensive calculation based on three factors: the annual peak solar radiation hours (PSH) at the deployment site, the average daily power consumption of the facility (including standby and operational cycles), and the available capacity of the energy storage battery (taking the depth of discharge, DoD, into account).

4.4 Power Consumption and Power Budget

4.4.1 Official Power Consumption List

The following is the complete quotation of the "HEISHA Model Power Consumption List" (copied verbatim):

type	UAV Configuration & Air Conditioning	Standby power consumption	maximum power dissipation	remarks
DCAP V1	M3T	20W	135W	12V (screened boost module), remote control & drone synchronous charging & 1 fan
DCAP	M4	20W	132W	12V (aluminum-shell boost module): drone charging + 1 fan (remote control does not charge)

type	UAV Configuration & Air Conditioning	Standby power consumption	maximum power dissipation	remarks
D80	M4	50W	500W	
D135	M350+1.5P air conditioner	90W	2400W	
D135	M350+D80 Air Conditioner	90W	1200W	

Note: This list covers only five configuration combinations and does not include models such as D65, D200, D250, D90, or DCAP MINI/LITE/INBUILT/PRO. The power consumption data for each product below are sourced from the respective product specification pages.

4.4.2 Power Consumption Comparison Table by Product

product	Standby power consumption	Operating/Maximum Power	data sources	remarks
D65	≤80W	≤1200 W (rated power, including full-load charging control for the air conditioner)	D65 Product Page	
D80	≤100W	≤ 800 W (operating power consumption includes charging); input power: 800 W	D80 Product Page	Power consumption: 500 W refers to the sub-component power; the ≤ 800 W specified on the product page represents the upper limit of the total system operating power consumption. Since these two definitions differ, this article uniformly adopts ≤800 W.
D135	≤100W	≤ 2800 W (operating power consumption includes charging); input power: 2800 W	D135 Product Page	2400 W/1200 W represent the individual power ratings for different air-conditioning configurations; ≤2800 W is the overall system upper limit, and this article uniformly adopts ≤2800 W.
D200	≤100W	Input power: 2800 W (maximum for the entire unit); per-item maximum power: 2000 W; charging module side: 3000 W	D200 Product Page	The three values are calculated using different criteria (maximum value per sub-item / total system input / module rated value); this article uniformly expresses them based on a total system input of 2800 W.
D100	—	Maximum power: 800 W	D100 Product Page	The standby power consumption is not specified; it is provided in Appendix E.
DCAP	≤10W	≤ 120 W (operating power consumption includes charging); input power: 120 W	DCAP Product Page	
DCAP V1	20W	135W	Power Consumption List	
DCAP	—	Standard operating condition: ≤ 150	DCAP MINI	The standby power consumption is not

product	Standby power consumption	Operating/Maximum Power	data sources	remarks
MINI		W; peak operating condition: ≤350 W	Product Page	specified; it is provided in Appendix E.
DCAP LITE	—	Maximum power: 250 W	DCAP LITE Product Page	The standby power consumption is not specified; it is provided in Appendix E.
DCAP INBUILT	—	Maximum power: 120 W	DCAP INBUILT Product Page	The standby power consumption is not specified; it is provided in Appendix E.
DCAP PRO	—	—	DCAP PRO Product Page	Power consumption data is not currently available.
D250	—	—	D250 Product Page	Power consumption data is not currently available.
D90	"Low-power standby" (no specific value specified)	"Intelligent dynamic power regulation for extreme cold environments" (no specific value specified)	D90 Product Page	The product page provides only qualitative descriptions of "low-power standby" and "intelligent dynamic power regulation," without specifying any numerical values.
V200	—	Rated maximum power: 4500 W (MAX)	V200 Product Page	The standby power consumption is not specified; it is provided in Appendix E.
D330	—	Rated maximum power: 2500 W (peak ≤ 2500 W, duration ≤ 10 min)	D330 Product Page	The standby power consumption is not specified; it is provided in Appendix E.

4.4.3 D200 Power Conflict Analysis

The power rating of the D200 is described in existing documentation in three ways: a maximum power of 2000 W in basic specifications, a total system input power of 2800 W, and 3000 W on the charging module side. These three figures differ in their basis—maximum power per item, total system input limit, and module rated value. For external quotations and power distribution design, the total system input limit should be used consistently, with a margin provided in accordance with the method described in Section 4.4.5.

source	description	numeric value
D200 Basic Specifications	"maximum power"	2000W
D200 Power Supply and Energy	"Main power supply: AC 220 V (input power 2800 W)"	2800W
D200 Power Supply and Energy	"Operating power consumption (including charging)"	≤2800W
D200 drone charging	"ACK Charging Module – Maximum Power"	3000W（14S）

The values at the four locations are 2000 W, 2800 W, 2800 W, and 3000 W, respectively, which are inconsistent with one another. From an engineering perspective, a possible explanation is that 2000 W represents the base power excluding the air conditioner; 2800 W represents the full-load power including the air conditioner; and 3000 W represents the maximum capacity of the ACK charging module itself (though

limited by the overall power distribution capacity of the system). However, this is merely a hypothesis; the official confirmation from HEISHA is the definitive authority.

The same issue also applies to the D80 (power consumption list: 500 W vs. product page: 800 W) and the D135 (power consumption list: 2,400 W/1,200 W vs. product page: 2,800 W). It is recommended that the data definitions used in power consumption lists and product specification pages be standardized, and that the definition boundaries for "maximum power" be clarified—specifically, whether this includes the air conditioner, whether it includes peak charging power, and whether it refers to continuous power.

4.4.4 Air conditioning and heating power consumption

Air conditioners and heaters constitute the primary components of hangar power consumption and directly affect the power budget and utility power capacity planning:

assembly	Compatible models	voltage	power	Cooling capacity/Heating capacity	weight	noise	Temperature setting	remarks
Compressor refrigeration	D80.D135	220V/110V	280W	Cooling capacity: 550 – 800 W	13KG	<45db	16–32 °C, 4th setting	
1.5 HP compressor air conditioner	D200	220V~240V/50Hz 1ph	Refrigeration rated power: <1350 W; heating rated power: 2000 W	Cooling capacity: 3500 W ± 10% (thus, it should be ± 10%)	48kg	—	—	Refrigerant R410/R22/640g; dimensions 550 × 450 × 350 (mm)
1.5 HP compressor air conditioner	V200	220V/110V	1.5P	Cooling capacity: 1500 W	13KG	<45db	16–32 °C, 4 adjustable settings	
Integrated compressor air conditioner	D65	—	—	—	—	—	Maintain an internal temperature of 10 °C–35 °C and humidity ≤ 80 % RH	Built-in; parameters are not listed separately
Compressor air conditioner + temperatur	D250	—	—	—	—	—	—	The complete machine configuration; specific parameters

assembly	Compatible models	voltage	power	Cooling capacity/Heating capacity	weight	noise	Temperature setting	remarks
e and humidity sensor								shall be verified against the configuration list.
PTC heater (optional)	D80、D135、D200、V200	220V	Steady-state power: 400 W; impulse power: 1000 W	—	—	—	—	Fan operating voltage: 220 V
radiator fan	DCAP、DCAP PRO	—	—	—	—	—	—	No compressor; heat dissipation is provided solely by the fan.

Note: "3500W ±10%" is a notation that should instead be written as "±10%." This article retains the original notation while providing an explanatory note.

4.4.5 Power Budgeting Methodology

For a custom project, it is recommended that the power budget be prepared according to the following steps:

1. Determine the baseline load: the continuous power consumption of the control system, communication modules, and sensors (typically a portion of the standby power consumption);

2. Superimposed functional loads: charging module power (select the ACK model based on the actual compatible device), air conditioner/heater power (select based on the deployment ambient temperature);

3. Calculate the peak power: assume all loads operating simultaneously under worst-case conditions; note that the inrush power of the PTC heater (1000 W) is substantially higher than its steady-state power (400 W);

4. Margin Reserve: It is recommended to reserve a margin of 20%−30% above the peak power to accommodate startup surges, aging-related degradation, and future expansion;

5. Determine the required mains power capacity: determine the circuit breaker capacity and cable cross-sectional area based on peak power × margin factor;

6. Additional calculation for off-grid scenarios: Daily average power consumption = standby power consumption × standby duration + operating power consumption × operating duration; energy storage capacity ≥ daily average power consumption × number of backup days during cloudy or rainy weather / depth of discharge.

4.5 Remote Control Power Supply and Remote Control

Remote control control board and remote control base

Heisha offers two accessories — the remote control control board and the remote control base — to enable remote power-on/off and charging management for the remote control.

The remote control control board and remote control base are interface components customized according to the specific remote control model; their parameters are determined by the remote control model and charging solution used, and the interface specification sheet shall serve as the basis for component selection.

Remote power-on/off capability via remote control

The HEISHA Drone Warehouse supports remote power-on and power-off operations for the remote controller via API (corresponding to the rc_open/rc_close commands in the API). This is a unique capability that distinguishes HEISHA from certain competing products, enabling integrators to implement a fully automated workflow in the cloud-based scheduling platform: "remote wake-up of the remote controller → launch the drone → execute the mission → recover the drone → shut down the remote controller."

Engineering challenges in simultaneous charging of remote controls and drones

The list of technical challenges records the following practical issues related to remote-control charging:

"DCAP remote controller and drone charged simultaneously; the entire system shuts down."

"During charging of the DCAP V3 M4E, the centering function cannot be released; when the remote control and the M4E drone are charged simultaneously, the airport will go offline."

These issues indicate that, in DCAP-series vehicle-mounted battery packs,

simultaneous charging of the remote controller and the drone may cause overall system overload or communication anomalies. From an engineering perspective, this may be related to DCAP's DC12V input power limit (120 W): when the remote controller and the drone are charged simultaneously, the total power may exceed the power supply's capacity, causing the system to experience power loss or restart.

The underlying mechanism of this issue is the competition between charging power allocation and power supply for communication links: when the remote controller and the UAV are charged simultaneously, the total system input approaches its upper limit, compressing the gateway's power supply margin and resulting in an "airfield offline" state. Key mitigation measures include calculating the input power based on peak operating conditions, configuring independent power supply branches for the gateway and communication links, and implementing time-sharing or derating in the charging strategy.

4.6 Electrical Safety and Protection

Summary of Protection Mechanisms

HEISHA crushers provide multi-level protection for electrical safety; the following are the clearly defined protection mechanisms for each model:

Protection type	Compatible models	explain
Overcurrent/Overvoltage Protection	D65	Mains power input terminal
Earth leakage protection	D65	Mains power input terminal
UPS Battery Protection	D65	Overcharge and over-discharge protection, short-circuit protection
Charging circuit short-circuit protection	D65	Charging module end
Emergency stop button	D65	Forward physical emergency stop switch of the hangar
Anti-backflow	D80, D135, DCAP, DCAP MINI, ACK series	Standard charging circuit
Prevent over-discharge	D80、D135、DCAP	One of the three key elements of charging protection
Temperature Monitoring	D80 、 D135 、 DCAP 、 ACK2000	Charging automatically stops when the battery temperature is <0 °C or>45 °C (ACK2000)
Overvoltage/overcurrent/reverse-polarity protection	In-vehicle embedded storage unit	Power supply system compatible with vehicle cigarette lighters and chassis power supplies
Overload/Short-circuit/Surge Protection	D90	Multi-stage lightning protection, surge protection, and short-circuit protection for fully electrical circuits
OVP/Undervoltage/OCP	ACK2000	For details, see Section 4.2.2, the ACK2000 parameter card.

Battery temperature protection window

The battery temperature protection window for the ACK2000 automatically stops charging and issues a notification when the temperature falls below <0 °C or rises above>45 °C. This window aligns with the safe charging temperature range for lithium batteries. In extremely cold environments—such as when the D90 is deployed at −40 °C—the battery temperature must first be raised above 0 °C via the heating system before charging can begin; this is one reason why the D90 is configured with the "extreme cold heating start threshold ≤10 °C: automatic heating activation" setting.

Altitude derating

The ACK2000 has an altitude adaptation limit of ≤3,000 m; beyond this limit, the device must operate at a derated power level, with power reduced by 10% for every 1,000 m increase in altitude.

The high-altitude adaptability of the complete aircraft must be verified simultaneously with the derating of the charging module, the cooling degradation at low air pressure in the air conditioning system, and the sealing performance (see sections 4.2.2 and 5.6). For high-altitude applications, power distribution and temperature control should be configured according to the corrected capacity; it is not advisable to directly apply parameters derived for low-altitude conditions.

EMC and Electromagnetic Shielding

The in-vehicle embedded equipment housing incorporates an internal electromagnetic shielding layer, ensuring stable device operation and clean signals within the in-vehicle environment. This is critical for EMC compatibility when multiple electronic devices coexist in the in-vehicle environment (in-vehicle radio, navigation systems, and UAV communication links).

Certification Information

Product pages for models such as the D80 and D135 specify "Industry certifications: CE/FCC/RoHS (for exported models)" and "Test reports: reliability test reports issued by third-party institutions." The certificate numbers, covered models, and validity periods for these certifications have been uniformly verified and compiled in Chapter 8; this chapter does not repeat them.

The tested models covered by the existing certificates and test reports are concentrated in the D80, D135, DNEST, and DCAP series; compliance documents for the

D65, D90, D200, D250, energy storage cabinets, and ACK series are provided separately by product line (see 8.1.2 and Appendix E).

4.7 In-house developed RTK base station

Heisha provides self-developed RTK base stations for providing high-precision positioning references for drones.

(The original image accompanying the material, image63.png, was not embedded with the text; the original can be requested from Heisha.)

Figure 4-6: Self-developed RTK base station by Heisha

The self-developed RTK base station is delivered as a complete unit, serving as a supplementary means for aircraft hangar positioning. The base station's positioning accuracy, coverage radius, antenna configuration, and power supply method are configured according to site conditions; during model selection, the base station data sheet and field survey results shall prevail.

Supported satellite systems (GPS/BeiDou/GLONASS/Galileo)

Positioning accuracy (horizontal/vertical)

Communication Interfaces and Protocols

operating temperature range

Power Supply Specifications

Dimensions and Weight

Does it support network-based RTK/CORS access?

4.8 Electrical Layer Selection Checklist

The following checklist has been compiled based on Category 5 (Power Supply Management), Category 6 (Charging Management), and Category 8 (UAV Support) in the "Key Considerations for Customizing the HEISHA Machine Database" under the FAQ section; it is intended for use by system integrators and the client's electrical engineers during equipment selection and project review.

Power Supply Management Selection Checklist

order number	Assessment Item	Option/Fill in	remarks
5.1	Is a rear UPS necessary?	□ Yes □ No	For emergency power supply to critical loads
5.2	Is a front-end UPS power supply required?	□ Yes □ No	Features voltage regulation, power regulation, and boost functionality
5.3	Is it necessary to connect solar photovoltaic panels?	□ Yes □ No	D200/D90 supports optional configuration
5.4	What are the input voltage specifications?	□ 110 V □ 220 V □ Wide voltage range: 100–240 V □ DC 12 V □ DC 24 V	Must be compatible with the on-site power supply conditions
5.5	Is it necessary to report the power supply operating status and faults?	□ Yes □ No	Report via API/MQTT

Charging Management Selection Checklist

order number	Assessment Item	Option/Fill in	remarks
6.1	Charging power/current requirement?	_____W / _____A	Drones battery specifications must be matched
6.2	What security measures are required?	□ Anti-backflow □ Anti-over-discharge □ Temperature monitoring □ OVP □ OCP □ Others_____	ACK2000 provides the most comprehensive protection.
6.3	Is the power-on/off or switchboard functionality required?	□ Yes □ No	Used for remote power-on and power-off via the remote control
6.4	How can the stability of contact charging be ensured?	Return method: □ Gravity □ Push rod	Return-to-center accuracy directly affects charging reliability.
6.5	Charging compatibility (center alignment)?	Compatible devices: _____	Ensure that the tripod is compatible with the centering mechanism.

Drone-Assisted Model Selection Checklist

order number	Assessment Item	Option/Fill in	remarks
8.1	Do you need a charging stand?	□ Yes (Model: _____) □ No	DJI M350 / MAVIC3 E/T / M4 E/T
8.2	Is a battery modification or switching board required?	□ Yes □ No	Battery modification/swapping boards are customized according to the specific model; specifications are provided in the interface specification sheet.
8.3	Is a remote control base required?	□ Yes □ No	The remote control base is customized according to the remote control model; specifications are provided in the interface specification sheet.
8.4	Is RTK assistance from a base station required?	□ Yes □ No	In-house developed RTK base stations are delivered as complete units; coverage radius and accuracy are determined by site configuration.

Charpter 5 L0: Hull Structure and Environmental Adaptability Design

5.1 Overview of Environmental Challenges and Technological Responses

As infrastructure deployed outdoors over extended periods, Drone docks must withstand the combined effects of a variety of extreme environmental factors. The table below summarizes the primary environmental factors, their corresponding failure modes, technical countermeasures for HEISHA, and verification methods:

environmental factor	Typical failure mode	HEISHA Response Measures	Verification methods
Low temperature (<-20 ℃)	Decreased activity of lithium batteries and restricted charging; low-temperature board crashes; material embrittlement; sealing components hardening and failure	PTC heating / three-stage temperature control strategy; constant cabin temperature of 5 ° C – 25 ° C; pull-out gel battery; high IP-rated encapsulated control board	Full-cycle load test of the low-temperature chamber; acceptance criteria are provided in 8.6.2
High temperature (>50℃)	Overtemperature derating of electronic components; risk of battery thermal runaway; accelerated aging of seals	Compressor air conditioner for active cooling; thermal insulation layer; heat dissipation fan	Full-cycle operation of the high-temperature chamber under load + cabin temperature recording; acceptance criteria are provided in 8.6.2
Sand/dust	Wear of the drone's power supply, gimbal, and charging interface; mechanical movement jamming; blockage of the heat dissipation channels	Fully enclosed multi-stage dust protection; Teflon open components; multi-layer composite sealing strips	IP5X/IP6X dust-jet test; acceptance criteria are provided in 8.6.2
Salt spray corrosion	Sheet metal corrosion; jammed hinges; poor electrical contact due to oxidation of electrical connectors	C4-M corrosion protection rating; heavy-duty anti-corrosion coating; stainless steel fasteners; anodizing treatment	Neutral Salt Spray Test (NSS); acceptance criteria are provided in Section 8.6.2
Rain, snow, and accumulated snow	Water accumulation and leakage at the top; snow load-induced structural damage to the cabin; rainwater intrusion into the electrical compartment	Pyramidal four-slope pitched roof; snow load ≥ 120 kg/㎡; multi-stage door sealing	Rainfall test + 1.5 times the snow load static pressure; acceptance criteria are provided in Section 8.6.2
strong breeze	Door deformation/damage; aircraft overturning; vibration fatigue	Door closure withstands Category 12 typhoons (D65); integrated load-bearing base; multiple fixed mounting points	Wind tunnel test or equivalent wind load test; acceptance criteria are provided in Section 8.6.2
Condensation/Frosting	Circuit short-circuit corrosion; lens fogging; sensor malfunction	Dual closed-loop coordinated control of temperature and humidity; high-IP enclosure	Alternating humid heat + cabin temperature and humidity records; acceptance

environmental factor	Typical failure mode	HEISHA Response Measures	Verification methods
		for the control board; anti-condensation dehumidification system	criteria are provided in 8.6.2
high altitude	Thinning air reduces heat dissipation efficiency; changes in air pressure affect sealing.	ACK2000 altitude derating (power reduction of 10% per 1,000 m)	Full-unit high-altitude simulation or field testing; acceptance criteria are provided in Section 8.6.2.
Vehicle vibration	Loose fasteners; fatigue fracture at weld points; connector detachment	Automotive-grade main controller/terminals/wire harnesses; shock-absorbing mechanism; seismic reinforcement structure	Vehicle vibration spectrum test (ISO 16750-3); acceptance criteria are provided in 8.6.2

The core philosophy of integrated collaborative design:

The analysis of D90's scenario-related pain points explicitly identifies the structural deficiencies of conventional hangars: "Flat-roof structures are prone to the accumulation of snow and sand; their sealing designs are simplistic; they lack an integrated, coordinated design for dust protection, temperature control, and corrosion resistance; and they are unable to withstand composite extreme weather conditions over the long term." This critique highlights the core principle of environmentally adaptive design: protective measures cannot be implemented in isolation; instead, they must be integrated and coordinated during the structural design phase. For example:

The four-slope, sloped roof not only addresses the issue of accumulated snow but also reduces the water accumulation pressure on the roof's sealing surface, thereby indirectly enhancing waterproofing reliability;

PTFE open-end fittings not only resist deformation at both high and low temperatures, but their low coefficient of friction also helps reduce wear on the sealing surfaces caused by dust and sand;

High-IP-rated packaging for control boards not only prevents condensation but also protects the circuits from erosion caused by dust and salt spray.

This approach—where a single design decision simultaneously addresses multiple environmental issues — is a key technical feature that distinguishes the D90 from conventional aircraft hangars.

5.2 Extreme Cold Environment Design Kit

Chain of Low-Temperature Effects on the System

From an engineering perspective, the impact of low temperatures on UAV hangar systems constitutes a complete causal chain:

Decrease in ambient temperature

│

├──→ Increased viscosity of lithium-ion battery electrolyte → Increased internal resistance → Reduced discharge capacity → Restricted or impossible charging

│ └──→ Voltage drops sharply during high-current discharge → Flight controller loses power

│

├──→ Parameter drift in control board components → Timing anomalies → Low-temperature crashes

│

├──→ Increased hardness of the seal (rubber/silicone) → loss of elasticity → seal failure → ingress of water vapor/dust

│

├──→ Ductile–brittle transition in metallic materials → increased fracture risk under impact loading

│

└ ─ ─ → Temperature differential between inside and outside the cabin → Condensation and frosting on the inner walls → Short-circuit corrosion in the circuit → Sensor malfunction

Only by understanding this influence chain can we grasp why designing for extremely cold environments is not simply a matter of "adding a heater" to solve the problem.

D90 Extreme Cold Response System

The D90 currently offers the strongest extreme-cold adaptability among the HEISHA product line; its response system covers the following aspects:

Temperature operating range:

parameter	price	explain
Operating temperature range (outdoor environment)	-40℃～+65℃	The customer needs to provide advance notice; configurations will be provided according to the specific environment.
Cabin constant-temperature operating range	5 ° C ～ 25 ° C: intelligent constant temperature control	Ensure the operating temperature of the drone battery, flight controller, and charging system throughout the entire process.
Extreme Cold Heating Start Threshold	Automatic heating activation at ≤10℃	Prevent low-temperature crashes and prevent battery charging failure
Temperature control accuracy	±3℃	Precise constant-temperature control

Three-stage temperature control strategy:

The D90 employs a three-stage temperature control strategy: "automatic preheating in low ambient temperatures → standby heat retention → constant operating temperature":

1. Automatic ambient-temperature preheating: When the ambient temperature falls below the heating-start threshold (≤10°C), the heating module is automatically activated to raise the cabin temperature to the minimum temperature at which the equipment can operate;

2. Standby thermal retention: During unoccupied operation, the cabin temperature is maintained within the thermal retention range at a low power level, reducing energy consumption and ensuring that the aircraft can take off at any time;

3. Constant cabin temperature: During the drone's mission, maintain the cabin temperature within a constant range of 5°C−25°C to ensure normal operation of the battery charging system and flight control system.

From an engineering perspective, the core value of the three-stage strategy lies in balancing the two objectives of "equipment safety" and "energy consumption control." If a constant temperature were maintained throughout the entire process, the heating power would remain high in an environment of-40 °C, placing substantial stress on the off-grid power supply system. The staged strategy allows the insulation temperature to be lowered

during non-critical periods, with full heating provided only when necessary.

Anti-frosting mechanism:

The D90 employs dual closed-loop coordinated control for cabin temperature and humidity, eliminating frost formation, dripping, and misting on the inner walls. This means that the system monitors not only temperature but also humidity simultaneously; when it detects that the cabin humidity is approaching the dew point, it actively activates dehumidification or adjusts the heating power to prevent water vapor from condensing on the inner walls.

Control board protection:

All in-cabin control panels are encapsulated with a high IP rating to prevent frosting, condensation, and water mist from corroding the circuitry. This represents a "defense-in-depth" strategy: even if the temperature control system fails to completely eliminate the risk of condensation, the encapsulation itself protects the circuit board from moisture erosion.

Battery compatibility:

Pull-out gel batteries can be installed inside the compartment to accommodate low-temperature environments. Compared with conventional lead-acid batteries and lithium batteries, gel batteries experience less performance degradation at low temperatures, making them suitable as backup power sources or energy storage units in extremely cold environments. The pull-out design facilitates on-site replacement and maintenance.

Low-temperature performance of other models

type	Lower operating temperature	Low-temperature heating configuration	remarks
D90	-40℃	High-power custom low-temperature heating module (compatible with extreme cold start at-40 °C)	Three-stage temperature control, ± 3 ° C accuracy
D80	-20℃	PTC heater (optional); steady-state 400 W / pulse 1,000 W	Supports customized high-temperature/low-temperature settings
D135	-20℃	PTC heater (optional); steady-state 400 W / pulse 1,000 W	Supports customized high-temperature/low-temperature settings
D200	-20℃	PTC heater (optional); steady-state 400 W / pulse 1,000 W	Supports customized high-temperature/low-temperature settings
V200	-20℃	PTC heater (optional); steady-state 400 W / pulse 1,000 W	
D65	-10℃	The built-in integrated compressor air conditioner maintains a temperature of 10 °C–35 °C.	The air conditioner also provides heating functionality (not specified).

type	Lower operating temperature	Low-temperature heating configuration	remarks
DCAP	-10℃	Heat dissipation fan (for cooling only, without heating)	For low-temperature applications, configure at the lower limit of-10 °C; heating capacity is provided in Section 5.2.
DCAP MINI	0℃	Heating module available as an optional option	Operating environment temperature: 0 °C to 55 °C
DCAP LITE	-5℃	No heating (cooling fan)	
DCAP INBUILT	-5℃	No heating (cooling fan)	
D100	-20℃	—	
D250	—	Compressor air conditioner + temperature and humidity sensor	Operating temperature is not currently provided.

PTC Heater Parameters

The PTC heater is an optional heating component shared by the D80/D135/D200/V200 models:

parameter	price
working voltage	220V
Fan operating voltage	220V
Steady-state power	400W
Impact power	1000W

From an engineering perspective, the inrush power of a PTC heater (1000 W) is 2.5 times its steady-state power (400 W). In a power budget, if multiple devices are started simultaneously for heating, the superposition of inrush powers may cause instantaneous overloading. It is therefore recommended that the staggered start-up or soft-start strategy for the heaters be considered in the power distribution design.

Thermal insulation structure

D250: Features an internal thermal insulation layer that reduces heat exchange between the interior and exterior of the compartment, thereby lowering heating and cooling energy consumption.

D65: An air conditioner with a built-in integrated compressor, maintaining a stable internal environment of 10°C–35°C and humidity ≤ 80% RH (no condensation).

V200: Container-style design, equipped with a compressor air conditioner and thermal insulation protection.

The insulation layer is configured according to the environmental package: models designed for extremely cold conditions incorporate an insulation layer between the cabin wall and the door assembly and are equipped with PTC heating; models designed for ambient temperatures primarily rely on sealing and air-conditioning for temperature control and do not include a dedicated insulation layer.

5.3 Extreme Dust and Corrosion-Resistant Environment Design Package

Extreme Dust Environment Challenge

The Gobi Desert and open-pit mining areas are subject to persistent wind-blown sandstorms; when dust enters the cabin, it can wear down the drone's power system, the gimbal's precision components, and the charging interface contacts, thereby increasing equipment failure rates and necessitating frequent cleaning and maintenance. Fine sand may also be drawn into the cabin through a negative-pressure effect (caused by airflow changes during fan operation and cabin door opening and closing); even the smallest gaps can serve as pathways for dust ingress.

D90 Jidun Response System

Fully sealed structure:

The hangar access hatch features a fully sealed design, with the opening constructed from Teflon material, which effectively withstands a wide range of low-temperature and high-temperature environments and prevents deformation;

The multi-layer composite sealing strip provides complete circumferential sealing, ensuring that the hatch closes without any gap;

The complete-seating joint sealing process prevents sand and wind-driven negative pressure from backflow into the cabin;

Once the multi-stage door sealing structure is closed, it forms an independent airtight compartment, providing a multi-layered barrier against dust, water, and salt spray.

Rationale for selecting PTFE material:

From an engineering perspective, the selection of PTFE rather than conventional rubber seals for the opening is based on the following considerations: -PTFE has an extremely wide temperature resistance range (−200 °C to +260 °C), so it will not undergo

hardening or softening deformation within the D90 nominal operating range of −40 °C to +65 °C; -PTFE has an extremely low coefficient of friction (0.04−0.1), making it less susceptible to failure due to frictional wear in dusty environments; -PTFE is highly chemically inert and remains unaffected by corrosive media such as salt spray, acids, and alkalis; -Its disadvantages include a higher cost than conventional sealing materials and lower elasticity compared with rubber, which necessitates integration with a clamping structural design.

Dust protection:

Description: "Long-term deployment in mining areas or deserts; no dust accumulation inside the housing; protects the gimbal lens, charging contacts, and motor."

IP Protection Grade Gradient Table

The following are the product-specific approval results for the IP protection levels of each product:

product	IPgrade	source	remarks
D65	IP55 (aircraft hangar main structure)	D65 Product Page	Supports custom upgrade to IP65
D80	IP54	D80 Product Page	
D100	IP54	D100 Product Page	
D135	IP54	D135 Product Page	
D200	IP54	D200 Product Page	
D250	—	D250 Product Page	No IP level has been provided at this time.
D330	IP54	D330 Product Page	
D90	IP65	D90 Product Page	Full cabin protection against dust, water splashes, and heavy rain erosion
V200	IP54	V200 Product Page	
DCAP	IP54	DCAP Product Page	Enclosure IP54
DCAP MINI	IP54	DCAP MINI Product Page	
DCAP LITE	IP54	DCAP LITE Product Page	
DCAP INBUILT	—	DCAP INBUILT Product Page	No IP level has been provided at this time.
DCAP PRO	—	DCAP PRO Product Page	No IP level has been provided at this time.
ACK2000	IP54	ACK2000 Product Page	Dustproof and splash-proof
HEISHA Energy Storage Cabinet	IP64	Energy Storage Cabinet Product Page	Rain protection rating

Note: IP ratings are ranked from lowest to highest as IP54 → IP55 → IP64 → IP65.

IP54 indicates Grade 5 dust protection (preventing the accumulation of harmful dust) + Grade 4 water resistance (splash protection); IP55 adds protection

against water jets; IP64 provides complete dust protection + splash protection; and IP65 provides complete dust protection + protection against low-pressure water jets. D90's IP65 rating directly reflects its positioning for extreme environments.

Salt Spray Corrosion Mitigation

corrosion mechanism:

In offshore areas, marine salt fog continuously corrodes sheet metal, hinges, and electrical connectors; conventional outdoor equipment consequently develops rust, water leakage, and seal failure within a short period. The essence of salt-fog corrosion is the electrochemical erosion of metal surfaces by chloride ions, which is particularly severe for carbon steel and ordinary aluminum alloys.

D90 Anti-corrosion System:

measure	explain
Salt spray corrosion resistance rating	C4-M: High corrosion resistance rating
Cabin shell	Thickened sheet-metal housing, with the entire unit coated with a heavy-duty anti-corrosion coating
fastener	All stainless steel fasteners ensure that rust-induced jamming is eliminated.
Surface finish	Multi-layer rust-inhibiting primer + heavy-duty anti-corrosion outdoor topcoat; UV-resistant and resistant to wind and sand abrasion
Maintenance Design	Independent side-mounted service hatch, centralized electrical layout, and convenient operation and maintenance

C4-M Corrosion Resistance Grade Description:

C4-M is a corrosion environment classification defined in the ISO 12944 standard, corresponding to "highly corrosive industrial atmospheres and highly saline coastal environments." M denotes medium durability (a maintenance interval of 7－15 years). This rating is suitable for long-term deployment in highly saline environments such as coastal and island areas.

Corrosion protection measures for other products:

D80: Supports customized salt-spray corrosion resistance (suitable for coastal environments); the housing features an outdoor oxidation-resistant coating;

ACK2000: Aluminum alloy die-cast housing with an anodized surface finish for corrosion resistance;

D65: The protective coating is an outdoor-specific powder coating that is UV-

resistant and aging-resistant, suitable for a wide temperature range of −20 °C to 60 °C; the main frame is constructed from high-strength galvanized steel sheets combined with aluminum alloy profiles;

D80/D135/D200: All charging electrodes are gold-plated to prevent contact resistance from increasing due to electrode oxidation.

Material rusting issue:

The list of technical challenges includes "material rusting issues," indicating that this is a real-world problem that has occurred in actual projects.

The management of salt spray issues comprises three layers: the material layer employs a C4-M coating system and stainless steel fasteners; the structural layer avoids dead zones for liquid accumulation and incorporates drainage design; and the maintenance layer involves inspecting the condition of the coating and fasteners during annual maintenance. These three layers together constitute the corrosion protection scheme for coastal projects.

5.4 Rain, Snow, and Structural Load Design

D90 Pyramid-shaped four-slope sloped-roof structure

The D90 features a closed, box-shaped cabin paired with a pyramid-shaped four-slope sloped roof structure; this design is specifically tailored for environments with rain, snow, and dust:

Sloped roof drainage design: rain, snow, and dust are allowed to slide off automatically under the influence of gravity, eliminating accumulated loads at the roof and enhancing resistance to wind and snow loads;

Comparison with traditional flat roofs: The design specifications for the D90 explicitly state: "Traditional flat-roofed hangar structures are prone to the accumulation of snow and sand." The horizontal surface at the top of a flat-roof structure accumulates precipitation, sand, and debris; over time, this accumulation may lead to: ① structural overload and deformation; ② water ingress through weak sealing points; ③ impaired heat dissipation due to accumulated sand and dust; and ④ damage to the waterproofing layer caused by freeze − thaw cycles during winter. A four-slope sloped roof fundamentally eliminates these problems.

Snow load capacity

The snow load at the roof of the D90 is ≥120 kg/㎡. Combined with the sloped-roof automatic snow-discharge design, accumulated snow is unlikely to persist continuously at the roof during actual operation; the 120 kg/㎡ load-bearing capacity therefore provides sufficient safety margin.

From an engineering perspective, 120 kg/㎡ corresponds approximately to 60 cm of fresh snow (with a density of about 200 kg/m³) or 30 cm of compacted snow (with a density of about 400 kg/m³). For most deployment scenarios, this metric is sufficient to withstand extreme snowfall events.

classification of wind resistance

product	classification of wind resistance	source	remarks
D65	When the door is closed, it can withstand a Category 12 typhoon (≥ 35 m/s); when in operation, it can withstand a Category 6 wind (≤13.8 m/s).	D65 Product Page	The only product that provides explicit wind resistance data
D90	—	D90 Product Page	The "Wind-and Snow-Resistant Structural Reinforcement Upgrade Kit" may be selected; the wind resistance rating shall be subject to the structural calculation report.
Other products	—	—	Follow the instructions indicated on each product; no unified wind resistance rating has been provided.

Note: D65 is the only product that provides explicit wind resistance rating data. Wind resistance parameters for other products — including D90, which is designed for extreme environments — are not provided. For deployment projects in areas prone to frequent typhoons (such as the southeastern coast, Japan, and Southeast Asia), the wind resistance rating is a critical selection criterion; it is recommended that HEISHA be contacted individually for confirmation.

Optional enhanced configuration

The D90 offers the following optional rain/ice and lightning-related add-ons: -Enhanced structural reinforcement kit for severe wind and snow conditions-Lightning protection system upgrade

Lightning protection configurations for models such as D80/D135/D330/V200 are optional: -External lightning rod (installed atop the T3 monitoring pole, with an

independent down conductor leading to the grounding system); -Lightning surge protector (front-end equipment installed in the built-in electrical cabinet, with an 8/20 μs waveform and In ≥ 5 kA)

5.5 Temperature and humidity control and condensation prevention

Air Conditioning Configuration Gradient Table

product	Air conditioning type	voltage	power	refrigerating output	weight	noise	Temperature setting	remarks
D80	Compressor refrigeration	220V/110V	280W	550-800W	13KG	<45db	16–32 °C, 4th setting	
D135	Compressor refrigeration	220V/110V	280W	550-800W	13KG	<45db	16–32 °C, 4th setting	Same as the D80 specifications
D200	1.5 HP compressor air conditioner	220V~240V/50 Hz 1ph	Cooling rated output: <1350 W; heating rated output: 2000 W	3500W ± 10% (thus, it should be ±10%)	48kg	—	—	Refrigerant R410/R22/640g; dimensions 550 × 450 × 350 (mm)
V200	Compressor air conditioner + thermal insulation layer	220V/110 V	1.5P	1500W	13KG	<45db	16 – 32 ° C, 4 adjustable settings	
D65	Built-in integrated compressor air conditioner	—	—	—	—	—	Maintain an internal temperature of 10 °C–35 ° C and humidity ≤ 80 % RH	Parameters are not listed separately
D250	Compressor air conditioner + temperature and humidity sensor	—	—	—	—	—	—	The complete machine configuration; specific parameters shall be verified against the configurationlist.

product	Air conditioning type	voltage	power	refrigerating output	weight	noise	Temperature setting	remarks
DCAP	radiator fan	—	—	—	—	—	—	Compressor-free
DCAP PRO	electric fan	—	—	—	—	—	—	Compressor-free
DCAP MINI	Built-in air-cooled temperature control	—	—	—	—	—	—	Optimize the internal thermal insulation design and spatial airtightness

Note: "3500W ±10%" is a notation that should read "±10%"; this article retains and annotates it accordingly.

Key Considerations for Selecting an Air Conditioning Mode

According to the key considerations for customization based on the FAQ, Category 3 (environmental adaptability requirements), the following dimensions should be evaluated when selecting an air-conditioning system:

Assessment Dimensions	option	Selection criteria
Air conditioning mode	Compressor / Semiconductor	Compressors are suitable for high-power cooling/heating applications; semiconductor-based solutions are suitable for low-power precision temperature control.
power	280W / 1.5P / Other	Calculated based on the cabin volume and the target temperature difference
control method	Automatic / Manual / Remote	D90 supports intelligent constant-temperature automatic control
Temperature acquisition method	Single-point in-cabin / multi-point / dual in-and out-of-cabin sensors	The D90 is equipped with dual in-cabin and out-cabin temperature sensors.
Heating method	PTC / Heat Pump / Electric Heating	PTC systems respond quickly but have high power consumption; heat pumps offer high efficiency but experience a decline in heating performance at low temperatures.
air duct design	—	Air supply can be categorized into side-side supply and top supply; select the appropriate type based on the cabin configuration.
Fan Design	—	Fan specifications and layout shall be determined based on the thermal load calculation.

Anti-condensation design

D90 Dual-Closed-Loop Interlocked Control:

The D90 employs dual closed-loop coordinated control for cabin temperature and humidity, eliminating frost formation, dripping, and atomization on the inner walls. The specific mechanism is as follows: -Temperature and humidity sensors continuously collect real-time cabin environmental data; -The control system calculates the dew point

temperature based on the current temperature and humidity; -When the cabin temperature approaches the dew point, the heating power is automatically adjusted or dehumidification is initiated, ensuring that the inner-wall temperature remains above the dew point at all times; -All cabin control boards are encapsulated with a high IP rating, serving as the final line of defense.

Dehumidification modes in the API:

In the HEISHA API, the air_conditioner_state enum value includes "3 = dehumidification," indicating that the air-conditioning systems in certain models support an independent dehumidification mode. This is critical for preventing condensation in high-humidity environments, such as tropical rainforests and the plum rain season.

Operating humidity range

product	Operating humidity range	source
D90	5% RH ~ 95% RH, no condensation	D90 Product Page
D65	10%–90% RH, no condensation	D65 Product Page
D80	—	Not specified on the D80 product page
D135	—	The D135 product page does not specify this clearly.
D200	—	Not specified on the D200 product page
V200	0%RH ~ 80%RH	V200 Product Page
ACK2000	5% ~ 95% (no condensation)	ACK2000 Product Page

5.6 High Altitude and Special Environments

High-altitude adaptability

ACK2000 charging module:

Altitude adaptation: ≤3,000 m; beyond this limit, the power rating must be reduced, with power decreasing by 10% for every 1,000 m increase in altitude.

The high-altitude adaptability of the complete aircraft is adjusted based on four factors: reduced air density causes a decrease in the compressor's air-conditioning cooling capacity (engineering experience indicates a reduction of approximately 5% – 8% for every 1,000 m of altitude increase); reduced fan heat-dissipation efficiency leads to an increase in the temperature rise of the electronic control system; changes in air pressure affect the sealing performance of the seals; and, under low air pressure, the breakdown voltage of the electrical clearance decreases. Accordingly, power and temperature-control redundancy are incorporated into the

overall aircraft configuration.

It is recommended that, in high-altitude deployment projects, the high-altitude suitability and derating curves of the complete equipment — particularly the air conditioning units, fans, seals, and electrical clearances—be verified.

explosion-proof

D65 supports a customized explosion-proof version, making it suitable for the operating conditions of specialized industries, such as petrochemicals and mining, where explosive gas environments are present.

The explosion-proof type and rating shall be determined according to the classification of the hazardous area where the project is located (GB 3836 series or the ATEX/IECEx system); certification shall be handled concurrently with the project approval process. D65 supports customized explosion-proof versions; the specific rating shall be subject to the conclusions of the project review.

Coastal/Island Deployment

The C4-M corrosion resistance rating of the D90 makes it suitable for long-term deployment in coastal, island, and high-humidity salt-spray environments.

The existing evidence from the classification society is a container certificate issued by the Midum Classification Society (Midum CLASSIFICATION SOCIETY), with the number GTD24S4332, and the certifying manufacturer is Guangdong Xinhui CIMC Special Transport Equipment Co., Ltd. For details of the certificate, refer to Section 8.5.3.

The certificate applies to container shells; the holder is Guangdong Xinhui CIMC. It certifies the structural strength and safety of the shell itself—including stacking capacity, shear and tension resistance, and corner-column load capacity—and does not cover the integrated machinery system within the container. For use in shipboard or maritime projects, class society approval at the complete-ship level must be obtained through a separate application tailored to the specific project.

(The facsimile copy of the original document, image77.png, was not included with this text; the original may be requested from Heisha.)

Figure 5-1 Photocopy of the Classification Society's container certificate (GTD24S4332)

5.7 Vehicle-borne and Mobile Environment Adaptability

Vibration and Impact

The primary difference between in-vehicle environments and fixed installations lies in the continuous vibration and impact loads. This places higher demands on the structural strength of the hangar, the reliability of fasteners, welding quality, and the contact stability of connectors.

DCAP MINI automotive-grade design:

DCAP MINI explicitly adopts automotive-grade design standards: -automotive-grade main control performance requirements; -automotive-grade connectors and wiring harnesses; -automotive-grade vibration isolation and stability.

These measures ensure the reliable operation of the DCAP MINI during vehicle operation. "Automotive-grade" means that its components and connectors have passed automotive industry standards for reliability testing—including vibration, temperature cycling, and Temperature and Relative Humidity testing—resulting in a reliability level higher than that of conventional industrial-grade products.

In-vehicle embedded storage unit

The vehicle-integrated embedded unit adopts a modular design and features the following vehicle adaptability characteristics: -Compatible with chassis from a wide range of vehicle models, enabling rapid deployment and mobile relocation; -Equipped with an integrated shock-absorption mechanism and an electromagnetic shielding layer to ensure stable equipment operation and signal purity in the vehicle environment; -Incorporates dual-mode GPS/Beidou positioning and 4G/5G communication modules, supporting real-time location transmission and remote task issuance; -Its power supply system is compatible with vehicle cigarette lighters and chassis power supplies, and includes overvoltage, overcurrent, and reverse-polarity protection.

ZIGLER In-Car Embedded Solution

The ZIGLER solution supports deep integration into specialized operational vehicles and features: -seismic-reinforced structures and dynamic attitude compensation capabilities, enabling takeoff and landing during high-speed movement; -a built-in edge computing unit capable of processing aerial photography data in real time and synchronously transmitting it back to the command center; -open interface protocols, ensuring compatibility with mainstream drone brands and mission payloads.

From an engineering perspective, "dynamic attitude compensation" is a key

technical capability: when a vehicle is traveling at high speed, it undergoes multi-degree-of-freedom motions including pitch, roll, and yaw; therefore, a UAV takeoff/landing platform must rely on inertial measurement and active compensation to maintain a level attitude; otherwise, the safety risks associated with takeoff and landing would be extremely high.

Installation method gradient

way to install	Applicable Products	explain
roof rack	DCAP	Standard roof installation
Trunk-type fixation	DCAP PRO	
Floor-mounted expansion bolts	D80、D135、D200、D250、D330	Concrete base
Drill-hole-free stand	D135、D200	Non-destructive ground installation method
Ground concrete fixation	D90	Permanently installed
Fangcang Integration	D90	Equipped on the mobile cabin platform
Rapid field hoisting and deployment	D90	Rapid deployment of temporary sites
Vehicle-mounted installation	D90, in-vehicle embedded, ZIGLER	

Deployment Considerations

Based on the key considerations for customizing the FAQ, Category 2 (structural transmission and deployment design) requires the following assessment during deployment:

Assessment Item	explain
Forklift/Crane/Wheel	Large aircraft hangars (D135:248 kg; D200:515 kg; D250:450 kg; D90:500 kg) require lifting equipment for assisted deployment.
Install the aluminum alloy base	Some models support installation on an aluminum alloy base, facilitating leveling and securing.
T3: coalescence or separation?	The integration approach between T3 monitoring stations and the aircraft hangar structure affects transportation and deployment flexibility.
Vehicle-mounted shock absorption	Vehicular applications must evaluate shock-absorption solutions and fastener anti-loosening measures.

Vehicle-mounted hangar illustration

image52.jpeg

image52.jpeg

Figure 5-2: Physical embodiment of the onboard embedded machine room

image53.jpeg

image53.jpeg

Figure 5-3: Installation effect of the in-vehicle embedded machine room

image54.jpeg

image54.jpeg

Figure 5-4 Internal structure of the in-vehicle embedded machine room

image55.jpeg

image55.jpeg

Figure 5-5 ZIGLER In-Car Embedded Solution

image56.jpeg

image56.jpeg

Figure 5-6: Integrated performance of the ZIGLER solution

image57.jpeg

image57.jpeg

Figure 5-7: Installation of the ZIGLER solution on special-purpose vehicles

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5.8 Environmental Sensing and Meteorological Monitoring

Sensor Configuration

The HEISHA Mining Warehouse supports the integration of multiple environmental sensors for real-time monitoring of the deployed environment's status:

sensor	CI	technical parameter	Compatible models
Cabin temperature sensor	—	—	D80 、 D135 、 D200 、 D65、DCAP、D90
Cabin humidity sensor	—	—	D80 、 D135 、 D200 、 D65、DCAP、D90
wind velocity indicator	RS485 Modbus-RTU	Power supply: 10–30 V DC; power consumption: ≤ 0.3 W; accuracy: ±(0.2 + 0.03 V) m/s; range: 0–70 m/s; resolution: 0.1 m/s; response time: <1s; operating temperature: −20 °C to +60 °C	D80、D135、D200
rain gauge	UART	Temperature range: −20°C to 85°C; core module diameter: 12.5 ± 0.15 mm; 304 stainless steel	D80、D135、D200

sensor	CI	technical parameter	Compatible models
		housing; power supply: 3.3 V	
Surveillance camera	—	Real-time monitoring of the interior/exterior of the hangar	D80、D135、D200、D65、DCAP
Extravehicular temperature	—	—	D90

D90 Environmental Perception System

The D90 offers the most comprehensive monitoring dimensions: -Cabin temperature-Ambient temperature-Cabin humidity-Equipment operating status-Charging status-Door status-Communication status

Alarm coverage: low-temperature anomalies, high-temperature anomalies, excessive humidity, door malfunctions, charging anomalies, and communication disconnections—comprehensive multi-dimensional alarms.

Weather Sensor Selection

Based on the key considerations for customizing the FAQ Category 4 (intelligent components), the following aspects should be evaluated when selecting weather sensors: -Six-parameter meteorological stations (temperature, humidity, atmospheric pressure, wind speed, wind direction, and precipitation) vs. simplified configurations (temperature and humidity only, plus wind speed and precipitation); -Requirements for audible and visual alarms and status indicator lights; -Requirements for the integration of fire protection equipment.

Incorporating environmental data into the decision-making closed loop

The one-click pre-flight function in the HEISHA API includes the check_rainfall and check_wind preliminary checks; this serves as the prime example of closed-loop control based on environmental sensing:

check_rainfall: Checks the rainfall sensor data; the rainfall enum value is 0 (no rain), 1 (light rain), 2 (moderate rain), or 3 (heavy rain). When rainfall exceeds the threshold, the system will wait for manual confirmation before proceeding with takeoff;

check_wind: Check the wind speed sensor data; if the wind speed exceeds the limit, similarly await manual confirmation.

This design embodies a complete closed loop of "environmental sensing → risk assessment → decision-based intervention," rather than merely using sensor data for

display purposes. When developing a cloud-based dispatching platform, integrators should make full use of these pre-inspection interfaces to avoid forcing aircraft to take off under adverse weather conditions, which could cause equipment damage.

Sensor reliability issues

The list of technical challenges records the following practical issues related to the sensor: - "Rainfall count values fail to reset to zero" - "Temperature and humidity sensors burn out, causing D135 to reset to center and resulting in a 485 offline state"

These issues indicate that environmental sensors may experience data anomalies or hardware failures during prolonged outdoor operation, thereby affecting the normal operation of the entire system. For example, burnout of temperature and humidity sensors may cause an RS485 bus anomaly, which in turn affects the communication of other RS485 devices.

The approach to addressing the issues described above is fault-tolerant design: when a sensor fails to respond within the specified timeout, it is degraded to the next most reliable state, and an ERROR event is reported; critical sensors (door limit switches, centering completion, and charging contact) employ dual-path redundancy or use mechanical limit switches as a backup; the communication bus is isolated by module, ensuring that a single point of failure does not propagate throughout the entire system. When designing the upper-layer system, integrators can treat status inputs based on this assumption.

5.9 Environmental Adaptability Design Verification

Current Status and Gaps in Environmental Adaptability Verification

HEISHA already has third-party test reports supporting its compliance in the fields of electrical safety and electromagnetic compatibility (GRGTEST conducted EMC immunity and emissions tests in accordance with EN 61000-6-2/6-4 and safety tests in accordance with EN 62368-1; all concluded as "Pass"). System certification and product compliance certificates are also fully in place; the certificate numbers and covered models are detailed in Chapter 8.

However, there is currently no written evidence for laboratory validation of the environmental adaptability program; the specific gaps are as follows:

High-and low-temperature operating tests and temperature cycling tests: No test reports are available. The only available basis is the nominal operating temperature range

specified in the product parameters (e.g., D90 −40 °C to +65 °C) and the design description (three-stage temperature control, ±3 °C temperature control accuracy); these constitute design specifications rather than measured results;

Salt spray test: D90 nominal C4-M corrosion protection rating, but no corresponding salt spray test report is available;

Dust and IP protection testing: Products bearing the nominal ratings IP54/IP55/IP64/IP65 shall have their third-party IP test reports filed separately by model (see Appendix E). IP54 certificates that have previously appeared in existing documentation were verified to have been issued for other products; therefore, they are not cited in this document (see 8.5.2).

Wind resistance and structural loads: D65 is nominally stated to be capable of withstanding Typhoon Force 12 (≥35 m/s) in the "cabin door closed" condition; D90 is nominally stated to have a "top snow load ≥120 kg/㎡"; neither has a wind tunnel test report nor a structural calculation report.

In-vehicle vibration and shock: DCAP MINI is rated for automotive-grade shock protection; no vibration test report is available.

Service life and durability: Only the DCAP MINI specifies a "service life ≥5,000 hours"; no cycle test data are provided. For the remaining products, apart from D65, which has a door opening/closing time ≤30 seconds per cycle, no opening/closing life indicators are provided.

The following list of verification items serves as a recommended framework; the test methods and criteria contained therein are engineering recommendations and do not represent the test records actually performed by Heisha. All data shall be subject to the third-party test reports or internal verification records provided by the official authority.

Recommended list of additional verification items

Verification Item	Recommended testing method	Recommended criteria	current state
High and low temperature operating tests	It is recommended that the test methods specified in IEC 60068-2-1/2 be referenced, with the specified duration maintained at both the upper and lower limits of the nominal operating temperature.	The equipment is functioning normally, with no performance degradation exceeding the specified limits.	Pending the third-party test report (see Appendix E)

Verification Item	Recommended testing method	Recommended criteria	current state
temperature cycling test	It is recommended that, in accordance with IEC 60068-2-14, a specified number of cycles be performed within the operating temperature range.	No crack at solder joints, no sealing failure, and no loose connectors	Pending the third-party test report (see Appendix E)
salt spray test	It is recommended that the ISO 9227 neutral salt spray test (NSS) be referenced, with the test duration determined according to the C4-M rating.	No significant corrosion, the seal is intact, and the electrical connections are functioning normally.	Pending the third-party test report (see Appendix E)
sand and dust test	It is recommended that the IEC 60529 IP5X/IP6X dust protection test methods be referenced.	No dust accumulation inside the cabin; mechanical operation is normal.	Pending the third-party test report (see Appendix E)
Rain/IP Protection Test	It is recommended that the spray/washdown test corresponding to the relevant IP rating in IEC 60529 be referenced.	No water ingress in the cabin; electrical insulation is normal.	Pending the third-party test report (see Appendix E)
Vibration and Shock (Vehicle-Borne)	It is recommended to refer to the ISO 16750-3 or MIL-STD-810G automotive vibration spectra.	Fasteners are not loose; weld points show no cracking; and connectors have not detached.	Pending the third-party test report (see Appendix E)
Snow load	It is recommended that an equivalent static load equal to 1.5 times the nominal value be applied.	The structure exhibits no permanent deformation, and the seal remains undamaged.	Pending the third-party test report (see Appendix E)
Wind resistance test	It is recommended to refer to wind tunnel testing or equivalent static load simulation.	The doors show no deformation, the entire aircraft shows no tilting, and the fasteners show no failure.	Pending the third-party test report (see Appendix E)
Service-life cycling test	Specified number of cycles for key moving components, including door opening and closing, centering mechanisms, and charging contacts	Functions are normal; wear is within the permissible range.	Pending the third-party test report (see Appendix E)
EMC electromagnetic compatibility	IEC/EN 61000 series	Radiated emissions, conducted emissions, and immunity all meet the specified limits.	☑ A GRGTEST report is already available, with the conclusion "Pass" (the range of tested models is specified in Section 8.4).
electrical safety	EN 62368-1	Insulation resistance, voltage withstand capability, and leakage current are within acceptable limits.	☑ A GRGTEST report is already available, with the conclusion "Pass" (the range of tested models is specified in Section 8.4).
Explosion-proof (where applicable)	It is recommended that GB 3836 or the ATEX/IECEx standards be consulted.	Obtain the appropriate explosion-proof certification	D65 supports a customized explosion-proof version; certification is handled alongside the project requirements.

Note: The "Recommended Test Methods" and "Recommended Criteria" listed in the table above are general recommendations from an engineering perspective and do not

constitute an assessment of the actual performance of HEISHA products. Before formal public release, the recommended content should be replaced with third-party test reports or internal validation data.

5.10 Environmental Adaptability Selection Checklist

Environmental Adaptability Requirements Checklist

The following checklist has been compiled based on Category 3 (environmental adaptability requirements) in the "Key Considerations for Customizing the 'HEISHA Machine Database' based on FAQs":

order number	Assessment Item	Option/Fill in	remarks
3.1	What are the requirements for low temperature?	Minimum operating temperature: _____℃	D90 reaches −40 °C; D80/D135/D200 reaches −20 °C; D65 reaches −10 °C.
3.2	What are the requirements for high temperature?	Maximum operating temperature: _____℃	D90 reaches +65 °C; D80/D135 reaches +55 °C; D200 reaches +50 °C/+55 °C
3.3	Is salt spray protection required?	□ Yes (Level: _____) □ No	D90 is C4-M; D80 supports custom salt spray protection.
3.4	Is dust protection required?	□ Yes (Level: _____) □ No	D90 provides fully enclosed multi-stage dust protection; D65 provides IP55 protection.
3.5	What are the IP rating requirements?	□ IP54 □ IP55 □ IP64 □ IP65 □ Others_____	See the IP gradient table in Section 5.3
3.6	Is a lightning protection device necessary?	□ Yes □ No	External lightning rod + surge protector (optional)
3.7	Air conditioning mode?	□ Compressor □ Semiconductor □ Fan □ Not required	Select based on the cabin volume and temperature differential requirements.
3.8	Air conditioner power?	_____W	D80/D135:280 W; D200:1.5 P
3.9	control method?	□ Automatic □ Manual □ Remote	D90 features intelligent constant-temperature automatic control.
3.10	Temperature acquisition method?	□ Single-point inside the cabin □ Dual sensors inside and outside the cabin □ Multi-point	D90 features dual in-vehicle and out-of-vehicle sensors.
3.11	Heating method?	□ PTC □ Heat pump □ Electric heating □ Not required	PTC steady-state 400 W / impulse 1000 W
3.12	air duct design?	_____	Air supply can be categorized into side-side

order number	Assessment Item	Option/Fill in	remarks
			supply and top supply; select the appropriate type based on the cabin configuration.
3.13	Fan design?	_____	Determine specifications and layout based on heat load calculations

Intelligent Component Checklist

Based on Category 4 of the FAQ (Intelligent Components):

order number	Assessment Item	Option/Fill in	remarks
4.1	Number of surveillance cameras?	_____individual	Warehouse interior/warehouse exterior/angle must be confirmed
4.2	Weather sensor?	□ Six Essential Elements □ Minimal Configuration □ Not Required	The six elements include temperature, humidity, atmospheric pressure, wind speed, wind direction, and precipitation.
4.3	Audio-visual alarm?	□ Yes □ No	Standard configuration for D80/D135/D200
4.4	status lamp?	□ Yes □ No	tri coloured lantern
4.5	Temperature and humidity sensor?	□ Yes □ No	Standard feature on most models
4.6	fire-fighting equipment?	□ Yes □ No	Optional fire suppression cartridges, smoke detection linkage, and smoke extraction solutions can be selected according to project requirements.

Environmental Conditions → Recommended Configuration Decision Table

ambient condition	Recommended Configuration	Recommended models	remarks
Minimum temperature <-20°C	PTC heating + gel battery + three-stage temperature control	D90	The D90 is the only model rated for-40 °C.
Minimum temperature: -20°C to-10°C	PTC heating (optional)	D80/D135/D200/V200	PTC steady-state 400 W / impulse 1000 W
Maximum temperature> 50°C	1.5 HP compressor air conditioner	D200	Cooling capacity: 3500 W ± 10%
Within 500 m along the coast / on islands	C4-M corrosion protection + customized salt spray protection + stainless steel fasteners	D90 (preferred); D80 (salt spray-resistant custom version)	D90 is rated C4-M
Mining area dust / Gobi wind-blown sand	IP65 + fully sealed + PTFE access components	D90	Fully enclosed multi-stage dust protection
Areas prone to frequent typhoons	Wind resistance ≥ Level 12 + ground-mounted concrete fixation	D65 (verified at Level 12); D90 (structural reinforcement kit)	The D65 is the only model with clearly documented wind resistance data.
Remote areas without grid	Photovoltaic energy storage	D90 / D200 (optional)	The solar irradiance-to-load

ambient condition	Recommended Configuration	Recommended models	remarks
electricity	off-grid system + low-power standby mode		ratio must be calculated.
In-vehicle mobile deployment	Automotive-grade main controller/terminals/wire harness + shock-absorbing mechanism	DCAP MINI / In-car embedded / ZIGLER	DCAP MINI is designed for automotive-grade applications.
High altitude> 3,000 m	ACK2000 derated operation + validation of overall equipment high-altitude parameters	Requires confirmation	ACK2000 power decreases by 10% per 1,000 m
explosive gas atmosphere	Explosion-proof version	D65 (customizable)	Certification is processed alongside the project.

Charpter 6 L3: Control and Perception Layer – Intelligent Control

6.1 Overview of the Control Architecture

The control system of the HEISHA processing facility adopts a three-tier layered architecture, forming a complete closed loop of perception–decision–execution from the local edge to the cloud. The primary consideration in designing this architecture is that, in field deployment environments with unstable network connectivity, the facility must possess local autonomy capabilities.

6.1.1 Three-level control hierarchy

top class	carrier	Java runtime environment Java	Core Responsibilities	Internet disconnection capability
Local edge layer	T100 Control Board	Embedded Linux, C-language programs	Drive control, sensor data acquisition, batch command execution, and safety interlocks	☑ Batch processing commands can still be executed even when the network is disconnected
Gateway layer	Gateway device (including HSC cloud migration software)	Android APK or Linux application	MQTT protocol conversion, object model encapsulation, bidirectional command validation, offline caching and retransmission	☑ Offline caching with automatic retransmission upon going online
Cloud Platform Layer	DNEST or a customer-built platform	Web/APP	Task scheduling, route management, video live streaming, data analysis, and remote operations and maintenance	✖Reliance on the internet

The T100 comprehensive command is a C-language program running on the T100 control board located within the control room; "when processing batch commands, it can operate without being affected by network instability and can continue executing all

commands even when the network is disconnected" (API documentation).

6.1.2 Perception–Decision–Execution Closed Loop

```
graph TB
subgraph Perceptual Layer
S1 [Temperature and humidity sensor]
S2 [Weather Station<br/>Wind Speed/Wind Direction/Rainfall]
S3 [Limit switch<br/>17 detection points]
S4 [Camera<br/>Inside/Outside the camera housing]
S5 [Smoke Sensor]
S6 [GPS/RTK module]
S7 [Charging Module<br/>Voltage/Current/Battery Status]
end

subgraph decision layer
T100 [T100 Control Board<br/>Embedded Linux / C Program]
GW [Gateway + HSC<br/>MQTT Physical Model Encapsulation]
Cloud [Cloud Platform<br/>DNEST / Self-built by customers]
end

subgraph execution layer
A1 [Hood motor]
A2 [Center-returning pusher/roller]
A3 [Air conditioner/Heater]
A4 [Charging Module]
A5 [Audio-visual alarm]
A6 [RGB three-color light]
A7 [Relay 8 Channels]
A8 [Remote Control Base]
```

```
end


S1 & S2 & S3 & S4 & S5 & S6 & S7 --> T100

T100 <--> GW

HW <--> Cloud

T100 --> A1 & A2 & A3 & A4 & A5 & A6 & A7 & A8
```

Figure 6-1 Hierarchical Control Architecture Diagram

6.1.3 Hardware Foundation of the T100 Control Board

The T100 is the main control PCB/main control board model used in the HEISHA Machine Warehouse; it is employed in multiple products, including the D80, D135, D200, and DCAP. It operates on an embedded Linux operating system, and its integrated instruction set is written in the C language.

Choosing the combination of embedded Linux and the C language rather than an MCU + RTOS means that the T100 has the following foundational capabilities: -Capable of running multithreaded tasks (parallel sensor acquisition, communication, and control logic); -Supports file system operations (offline data caching and log recording); -Supports network protocol stacks (MQTT, TCP/IP, and HTTP); -Supports remote firmware updates via OTA; -Capable of running more complex control algorithms (such as PID temperature control and multi-sensor fusion).

This hardware selection establishes a relatively high upper limit for local intelligence in the HEISHA machine storage system, while also providing room for subsequent functional extensions, such as edge AI inference.

6.1.4 The role of protocol translation at the gateway layer

HSC (HEISHA CLOUD) cloud access software is the core component at the gateway layer and serves as "intermediate software": on the one hand, it parses drone flight-control commands or MSDK; on the other, it packages them into cloud-accessible physical models. It is deployed as an Android APK or Linux application and runs on a remote-control device's Android system or on a local microcomputer.

This means that the gateway layer serves not only as a protocol converter but also assumes the following responsibilities: -Flight controller abstraction: standardizing flight controller commands from different drone brands and models into a unified MQTT object model; -State aggregation: consolidating the status of subsystems within the hangar into a

unified OSD/state report; -Command routing: distributing cloud-downstream commands to the corresponding local subsystems; -Offline buffering: caching data and events during network interruptions and automatically resending them upon recovery.

For integrators, understanding the role of the HSC is crucial: it serves as a bridge connecting the "hardware world of the data center" with the "cloud business world." If a customer chooses to build its own cloud platform instead of using DNEST, the HSC will still be required to perform the underlying protocol translation.

6.1.5 Communication Reliability Mechanism

The D90 product documentation explicitly lists four communication reliability mechanisms:

Bidirectional command validation: every downlink command requires an uplink acknowledgment

Resume from Last Known Good State: Continue from the last breakpoint after network interruption recovery

Offline caching: local storage of data during internet outages

Enable automatic data retransmission: automatically upload cached data once the network has recovered

This means that when designing a cloud platform, integrators must implement the events_reply response mechanism (when need_reply=1); otherwise, the aircraft-side system may assume that the command has not been delivered and trigger a retransmission or timeout.

6.2 Intelligent temperature control

6.2.1 The five competencies outlined in the framework outline

The "3. Performance and Intelligent Enhanced Customization" chapter of the product introduction document outlines five capabilities of intelligent temperature control:

1. Multiple energy-saving modes
2. Clock timing
3. Temperature range
4. Set a timer for completion of charging

5. Set the timer after closing the lid

The engineering implementation of temperature control capability can be fully reconstructed from the protocol side: the air conditioner's attributes, methods, and registers together form a complete control interface for temperature setpointing, mode switching, start/stop operations, and status feedback. The following section describes the capability boundaries based on verifiable protocol information; the function titles in the product documentation are mapped item by item to the specific registers and commands.

6.2.2 Verifiable temperature control capability on the agreement side

Air Conditioning Attributes and Methods

The API physical model defines an air-conditioner operating-state attribute, air_conditioner (of struct type), whose subfield air_conditioner_state has the following enum values:

enumerated values	meaning
0	Idle mode (no cooling, heating, dehumidification, etc.)
1	Cooling mode
2	Heating mode
3	Dehumidification mode
4	Cooling shutdown mode
5	Heating shutdown mode
6	Dehumidification Exit Mode
7	Refrigeration Preparation Mode
8	Heating Preparation Mode
9	Dehumidification Preparation Mode

Air conditioner temperature setting command: set_air_conditioner_temperature

Register-level temperature control parameters

The MODBUS register mapping table provides the following temperature control-related registers:

register	explain	Zoom/Value
Temperature 1 / Temperature 2 / Temperature 3 / Temperature 4	Four-channel temperature acquisition	temperature ×10+1000
PWM1 / PWM2 / PWM3	Three-stage PWM output	Value: 0–7
electric relay	Eight-way relay control	BIT0–BIT7: 0 = off, 1 = on
Operating mode	Current actual operating mode	0 = Off mode / 1 = Strong cooling mode / 2 = Heating mode (as above) / 3 = Air-cooling mode
WORKMODE	Set the operating mode	0 = Off mode / 1 = Strong cooling mode / 2 = Heating mode (as above) / 3 = Air-

register	explain	Zoom/Value
		cooling mode / 4 = Constant temperature mode
maximum temperature	Upper temperature threshold	—
minimum temperature	Lower temperature threshold	—

The WORKMODE register defines five possible values (including 4 = constant-temperature mode), whereas the "operating mode" feedback lists only $0-3$. During interfacing, WORKMODE should serve as the control side and operating mode as the feedback side; the behavior of constant-temperature mode on the feedback side must be verified during system integration testing (see Section 7.9.2, System Integration Testing Checklist).

6.2.3 Deriving control strategies from register capabilities

Based on the above register configuration, it can be inferred that the HEISHA temperature control system has the following hardware foundation:

Four-channel temperature acquisition (temperatures $1-4$) → enables multi-point temperature measurement and zoned temperature control within the cabin

Maximum/minimum temperature thresholds → enable temperature-range control (corresponding to the "Temperature Range" item in the outline)

Eight-way relay → enables independent control of multiple actuator units, including the heater, fan, and compressor

Three-stage PWM (0–7) → enables multi-level power adjustment for the fan/heater (corresponding to the "Multiple Energy-Saving Modes" section of the outline)

WORKMODE includes constant-temperature mode → supports constant-temperature hold strategy

This means that capabilities such as "multiple energy-saving modes" and "temperature ranges" specified in the system specifications have corresponding control interfaces at the hardware level: temperature setpoints, mode switching, and start/stop operations can all be commanded via a control instruction; energy-saving strategies are scheduled by the control program based on temperature differentials and standby flight plans, rather than relying solely on hardware efficiency.

6.2.4 D90 Temperature Control Accuracy Validation

The product specifications of the D90 Ultra-Cold Ultra-Dust Garage provide the most detailed temperature control parameters currently available:

parameter	metric
Temperature control accuracy	±3℃
Cabin constant-temperature operating range	5℃~25℃
Extreme Cold Heating Start Threshold	Automatic heating activation at ≤10℃
Temperature control strategy	Three-stage process: automatic preheating in low ambient temperatures → standby heat retention → constant operating temperature
Anti-icing mechanism	Dual closed-loop coordinated control of cabin temperature and humidity
Standby Heat Retention Mode	Low-power heat retention during unattended operation reduces energy consumption.

The three-stage temperature control (preheating → heat retention → constant temperature) is inherently an energy-saving design: during standby mode, only the heat-retention range is maintained; before flight, the temperature is raised to the operating range, thereby avoiding the need to maintain the operating temperature throughout the entire day. This strategy has been explicitly implemented on the D90; other models adopt it in a tiered manner based on their temperature-control configuration (whether they are equipped with a PTC and an air conditioner).

6.2.5 Recommended additional verification content

To make the description of temperature control capabilities provide practical engineering reference value for integrators, it is recommended that the following content be added:

Specific trigger conditions and power consumption comparison data for each energy-saving mode

Minimum granularity of clock timing and number of configurable time slots

Default scheduled charging duration and adjustable range after charging completion

Scheduled delay time and configurability after the lid is closed

Measured heating/cooling curve data at different ambient temperatures

Maximum heating/cooling capacity of the temperature control system and typical time required to reach the target temperature

6.3 Visual Intelligent Control

6.3.1 The three competencies listed in the framework outline

The product introduction document outlines three capabilities of AI camera intelligent control:

1. Visual inspection for the presence or absence of drones

2. Visual assessment of whether the drone has landed correctly

3. Visual assessment of the drone's charging status

Vision-related capabilities are presented as feature titles in product documentation; the specific algorithms and metrics are implemented on the client side. The part that can be empirically verified is the Vision SDK (AAR) and its integration boundaries: vision capabilities run on the Android client side and are not directly invoked by the cloud. The following section describes the capabilities and limitations based on these boundaries.

6.3.2 Empirically verifiable visual capabilities: Visual SDK AAR

The Visual SDK is delivered as an AAR package; the specific specifications are as follows:

project	explain
Distribution format	Android AAR binary package
function	Precise landing via QR code; remote landing at AB points
Compatible device model	DJI MAVIC 3 E, DJI M4E
Integration method	Integrate into an Android app developed using the DJI MOBILE SDK
Java runtime environment Java	Compatible with Android devices that can be operated via the DJI remote controller
Properties of QR codes	Static images, not dynamically generated; provided as a PDF attachment.
Libraries in the source code package	Precision Regression Library – DJI M4E/MAVIC3E (QRPL-M4E); Precision Regression Library – DJI MINI (QRPL-Mini)

Integration boundary: The visual SDK is provided in AAR form and can only be integrated into the Android app side (the remote-control side or a local Android device); cloud-based business software cannot call it directly. This means that the determination and results of visual-assisted landing remain on the device side, and the cloud can only obtain them indirectly through event or status reporting; this constraint must be incorporated into the architectural design from the outset.

The DNEST platform supports "visual-assisted return" and "uploading 2K source files"; however, these are functions at the scheduling level, while the underlying

implementation still relies on the execution of the Visual SDK AAR on the app side.

6.3.3 Key Distinction: Electrical Inspection vs. Visual Inspection

Evidence from the agreement side indicates that the detection of "whether the drone is present" and "charging status" is primarily achieved through electrical means rather than visual methods:

Drone presence detection (electrical method): -API property drone_in_dock: 0 = outside the pod (inorganic), 1 = inside the pod (organic) -Charging module register BIT4 − BIT5: battery detection status (DRONE_DETECT_UNKNOWN=0 / DRONE_DETECT_YES=1 / DRONE_DETECT_NO=2)

Charging status detection (electrical method): -Charging module registers BIT0−BIT3: 0x00 = not charged / 0x01 = charging ready / 0x02 = charging during shutdown / 0x03 = charging during startup / 0x04 = charging complete / 0x08 = fault-Charging voltage (voltage × 10), charging current (current × 10), battery level (0−100%), battery temperature (temperature × 10 + 1000) -API attribute drone_charge_state(struct): state (0 = idle / 1 = charging in progress), capacity_percent (0−100) -BIT6−BIT7: drone on/off status (DRONE_ON_UNKNOWN = 0 / DRONE_ON_YES = 1 / DRONE_ON_NO = 2)

It is recommended that the white paper separately describe "electrical inspection" and "visual inspection" as two complementary technical approaches:

Detection Dimensions	Electrical Testing	visual inspection
Are there drones?	☑drone_in_dock + battery detection port	Visual SDK on-device recognition; see section 6.3.2 for the scope of capabilities.
Charging status	☑ Multi-dimensional cross-validation of voltage/current/battery level/temperature	Visual SDK on-device recognition; see section 6.3.2 for the scope of capabilities.
Landing attitude/position	✗Electrical system cannot determine	☑ Precise landing via QR code; remote landing at designated A and B points
Has it been correctly assigned to the center?	Indirect determination of limit switches (coaxiality verification)	Limiting and visual reuse positioning; see 6.3.4

The advantage of electrical inspection lies in its independence from lighting conditions and lens contamination, resulting in high reliability; the value of visual inspection lies in its ability to assess the landing attitude and achieve precise alignment. The two methods complement each other rather than replace one another.

6.3.4 Engineering constraints for visual degradation

The engineering implication of the code as a fixed image:

Provided as a PDF attachment and not dynamically generated, this means that: -Each storage facility must have the QR code printed and permanently installed during deployment; -Once the QR code is damaged or obstructed, it must be manually replaced; -Dynamic encoding is not supported (e.g., embedding anti-counterfeiting information such as the current storage facility ID or timestamp); -When deploying across multiple storage facilities, it must be ensured that the QR codes are not confused with one another.

The real challenge of nighttime lighting:

The "Technical Issues to Be Resolved" list records the issue that "the searchlight used for nighttime drone visual landing is too bright, making it impossible to recognize QR codes." The record states that visual landing uses QR codes as reference markers, resulting in a conflict between nighttime illumination intensity and marker contrast. Potential solutions include controlling the angle and intensity of supplemental lighting, using marker materials resistant to overexposure, or switching to a degraded path that employs a combination of RTK and visual positioning.

6.3.5 Recommended additional visual indicators

To provide the description of visual intelligent control with engineering reference value for integrators, it is recommended that the following be added:

QR code recognition accuracy (measured data under different lighting conditions)

False alarm rate and missed detection rate

Identify response latency (the time from entering the field of view to completing recognition)

Light adaptation range (minimum/maximum illuminance)

Lens contamination and degradation strategies under rainy or foggy conditions

Nighttime landing lighting solution

Positioning accuracy for non-local landing at point AB

Specific implementation approach for visual-based determination of whether a drone has landed, whether its landing is correct, and its charging status (if a visual solution is indeed available)

6.4 Intelligent Fire Safety Management

6.4.1 The three competencies listed in the framework outline

1. Intelligent fire suppression trigger

2. Smoke alarm trigger

3. Temperature Control and Video Surveillance

Fire safety-related capabilities are presented in the product documentation under functional headings. The verifiable components include the smoke detectors, temperature monitoring, and alarm interconnection channels on the protocol side, as well as the multi-layered protection on the charging side. Detection methods and interconnection logic are determined in accordance with the fire safety solution selected as an optional component of the project.

6.4.2 Verifiable fire protection capabilities

API physical object properties:

smoke_value (float): smoke sensor value

emergency_stop_state (enum_int): Emergency stop button status; 0 = off / 1 = on

alarm_set command: alarm early-warning function

Patent evidence:

Two utility model patents pertain to fireball launch solutions: - "A drone storage facility that facilitates the replacement of fireballs and provides stable parking" (CN222202949U); - "A drone storage facility that facilitates transportation and incorporates fireballs" (CN222614939U).

The patent title suggests the following: -The fire protection solution employs fire extinguishing cartridges (rather than traditional solutions such as sprinkler or gas-based fire suppression); -It emphasizes "easy replacement," indicating that the fire extinguishing cartridges are consumables that require periodic replacement; -It emphasizes "stable parking" and "easy transport," indicating that the installation location and fixing method for the fire extinguishing cartridges are specifically designed.

The invention patent "A Specialized Charging Safety and Fire Protection Design for Uninhabited Areas" (application no. 2022109813045; publication no. CN115402138A) has been withdrawn; therefore, it is not listed here as a valid patent. It is included here solely for the purpose of documenting the technical direction; its content does not constitute prior-art assets.

6.4.3 Safety protection on the charging side (empirically verifiable)

Although the specific logic underlying fire safety coordination is lacking, there is substantial empirical evidence regarding safety protections on the charging side:

ACK2000: If the battery temperature is <0 °C or>45 °C, charging automatically stops and a notification is displayed.

Charging protection: OVP (overvoltage protection), undervoltage protection, OCP (overcurrent protection) thresholds and timing

Anti-backflow, anti-over-discharge, and temperature monitoring

Communicate with the BMS to retrieve battery capacity/temperature/cycle count

D65: "Supports battery status monitoring (voltage, temperature, cycle count); abnormal batteries are prohibited from takeoff."

6.4.4 Recommended supplementary description of the fire protection chain

Intelligent fire safety management is a critical safety function; it is recommended that the following comprehensive chain description be added:

link	Additional content required
survey	Smoke sensor model, sensitivity, installation location, and sampling frequency
judge	Trigger threshold, multi-level alarm logic, false alarm filtering mechanism
movement	Fire alarm trigger type (electrical/mechanical), release delay, coverage area
appear in the newspapers	The method name, event level, and whether a reply is required for the alert event
linkage	Whether automatic power disconnection, cover closure, and charging cessation are triggered after the fire extinguisher is activated
recover	Post-fire reset procedure and fire extinguisher replacement guidelines
standard	The applicable fire safety standard or test report number

The fire protection chain is described in four stages: detection (smoke detectors, temperature detectors, combustible-gas detectors) — decision-making (local T100 logic, with levels defined as ERROR/ALERT) — response (disconnection of charging circuits, activation of smoke extraction, or release of fire-extinguishing media) — reporting (EVENT push to the cloud platform and triggering of manual intervention). The components in each stage of the chain and the corresponding standards are selected according to the project-specific configuration plan; this document does not establish its own standard numbering system.

6.5 Drone compatibility and adaptation

6.5.1 Complete Compatibility List

The table below, detailing the compatibility of drones in the product introduction document, has been copied verbatim:

brand	type	Custom Aircraft Hangar	Customized charging and accommodation	Customized Deployment	Software
DJI	MAVIC3 E/T	✔	✔	✔	
DJI	M4 E/T	✔	✔	✔	
DJI	M300 E/T	✔	✔	✔	
DJI	M350 E/T	✔	✔		
DJI	M30 E/T	✔	✔		
DJI	MINI 3	✔	✔		
DJI	MINI 4	✔	✔		
Fengyi	ARK 40	✔	✔	✔	
Fengyi	ARK 20	✔	✔		
Fengyi	E15	✔			
Codyway	3F	✔	✔	✔	
Codyway	XXX	✔			
SKYDIO	SKYDIO 2	✔	✔		
SKYDIO	SKYDIO X2	✔			
SKYDIO	SKYDIO X10	✔			
AUTEL	EVO 2	✔	✔		
AUTEL	EVO MAX	✔	✔		
AEROSENSE	AS-VT01K	✔			
AEROSENSE	Aerobo PPK	✔			
AEROSENSE	AS-MC01-P	✔			
AERBORNE	HAWKER UAS	✔			
Flaredynamic	TETHER DRONE	✔			
XER-TECH	X8	✔			

brand	type	Custom Aircraft Hangar	Customized charging and accommodation	Customized Deployment	Software
XER-TECH	DELTA	✔			
PROTEC	HERCULERS 2	✔			
PROTEC	HERCULERS 10	✔			
PROTEC	HERCULERS 20	✔			
T-MOTOR	T-DRONE 690 pro	✔			
DRONEGY	HEIFU Pro	✔	✔		
DRONEGY	FPV 7.1″	✔	✔		
DRONEGY	FPV 10.1″	✔	✔		
Cross the sea	Lingxun ZT-25V	✔			
Heavenly Path	VTOL	✔	✔		
Baina Zhixing	(Model not specified)	✔			
Danateq	(Model not specified)	✔			
Aidrone	(Model not specified)	✔			
Drone	(Model not specified)	✔			
Geofencing	(Model not specified)	✔			
Heptaairborne	(Model not specified)	✔			
Skyeair	(Model not specified)	✔			
Droneexpress	(Model not specified)	✔			
Infovision	(Model not specified)	✔			
Italdron	(Model not specified)	✔			
Accelligence	(Model not specified)	✔			

6.5.2 Data Statistics and Quality Issues

Statistical Summary: -Total: 44 records-Brands involved: 22 (including suspected non-brand names such as "Drone" and "Geofencing") -Full three-tier compatibility (aircraft + charging + software): 5 entries (DJI MAVIC3 E/T, M4 E/T, M300 E/T; Fengyi ARK 40; Kodiwei 3F) -Two-tier compatibility (aircraft + charging): 12 entries-Aircraft-only customization: 27 entries

The compatibility list contains three types of correctable quality issues: first, the model names in the Kodiwei entries are placeholder names and should be replaced with the actual model names; second, 11 brands have only their brand names registered

without corresponding model names, so their compatibility depth can only be recorded as a custom entry in the model library; third, some entries appear to be informal brand names. These issues do not affect the compatibility conclusions for the models already listed, but they reduce the list's traceability; it is therefore recommended that the list be finalized after each entry has been verified against the original records specified in Section 6.5.1.

These data quality issues will undermine the credibility of the compatibility list; it is recommended that model names be completed or incomplete entries be removed.

6.5.3 In-depth Analysis of Three-Level Adaptation

Compatibility level	meaning	technical requirement
Custom Aircraft Hangar	Cabin dimensions, apron, and centering mechanism are compatible with this aircraft model.	Structural component adjustment and limit-point matching
Customized charging and accommodation	Charging port, battery protocol, and charging dock compatibility	Charging module matching, electrode position adjustment, and BMS communication compatibility
Customized Software Deployment	HSC/DNEST has completed the flight-control interface integration for this aircraft model.	MSDK/PSDK/MAVLINK command parsing and physical model mapping

Many models offer only "hub customization" ✔ , indicating that HEISHA has completed structural compatibility, but that charging and software integration have not yet been completed or require additional customization. For integrators, choosing a model that offers only hub customization means that they must either undertake the charging and software-level compatibility work themselves or commission HEISHA to complete it.

6.5.4 Three compatible technical elements

Return-to-center limit:

The centering system detects the drone's position using limit switches; Bit16-0 has a total of 17 detection points. Since the landing gear spacing varies across different aircraft models, the positions of the limit points must be adjusted to achieve accurate centering.

Remote control base:

The remote-control base register supports dual stations (Remote Control 1/Remote Control 2), each providing: -Online status (0 = offline / 1 = online) -Temperature (Temperature × 10 + 1000) -Humidity (Humidity × 10) -Switch status (BIT0: 0 = remote control powered off / 1 = remote control powered on) -Command (1 = remote control switch-on/off)

The API provides the rc_open and rc_close commands, which are marked as "HEISHA-exclusive" features.

Charging compatibility:

Battery type adaptive: 0=Unknown / 2=2S / 3=3S / 4=4S / 6=6S / 12=12S

ACK series tiers: ACK150 (3S/4S), ACK800 (6S－12S), ACK2000 (dedicated to TB100C)

High-current relay: supports 2−18s

6.5.5 Flight control platform compatibility

The HSC Cloud Software Series supports the following flight control platforms:

Flight Control Platform	HSCedition	remarks
DJI MSDK	HSC-MSDK-DJI	Basic version: 42 items / 312 items
DJI PSDK	HSC-PSDK-DJI	—
MAVLINK Open-Source Flight Controller (PX4, ArduPilot, INAV)	HSC-MSDK-MAV	—
Fengyi Flight Control	Fengyi Flight Control Cloud-Based Basic Edition	—
Third-party encapsulated flight control	Accept customization	—

6.5.6 Boundary Declaration

In its FAQ section, when directly answering the question "Can HEISHA be used to create a wireless charging station?" it states:

"We can provide drone hangars that match the customized requirements... However, we cannot assist with modifications to the drone itself; that work can only be carried out by the drone manufacturer."

List five reasons: 1. The battery assembly must be positioned at the lowest point to serve as the landing surface; 2. No payload may be mounted beneath the battery; 3. The obstacle-avoidance camera or infrared ranging system below the battery requires adjustment, which constitutes a major structural modification; 4. The radio coil should preferably be integrated into the battery or positioned directly beneath it; 5. The coil's weight and efficiency must be adjusted by the manufacturer based on payload capacity, power output, and flight control requirements.

This defines the product scope of Heisha: the company will not engage in drone

development or manufacturing; instead, it will focus solely on building aircraft hangar platforms and providing supporting software and hardware.

6.6 Alerting and State Awareness

6.6.1 Event Level 3 Framework

The EVENT alarm and error reporting system is divided into three levels:

rank	definition	Reporting Method	OSD appear in the newspapers
INFO	Dynamic notifications regarding the normal operation of the reporting system	When the register event flag is set, it is reported once and then cleared immediately.	Do not report via OSD
ERROR	Report non-fatal system faults; these do not affect the system's functional operation.	Perform fixed-frequency reporting in coordination with the reporting from each module.	Can be reported via OSD
ALERT	Report a critical system failure that affects the system's functional operation	Perform fixed-frequency reporting in coordination with the reporting from each module.	Can be reported via OSD

ERROR and ALERT can also be queried by actively fetching events_error_table / events_alert_table.

6.6.2 need_reply: semantics and events_reply: closed loop

events messages contain the need_reply field: -0: No response from the cloud platform required-1: Response from the cloud platform required

When need_reply=1, the cloud platform must respond via the events_reply Topic; the data must include a result field (0 = success).

This is a simple yet important mobile phone handling mechanism. When an integrator develops a cloud platform, it must respond to events with need_reply=1; otherwise, the control room may determine that the command has not been delivered. It is known that for DOOR_ALERT_REG 0x20410008, "Is a response required?" = y, indicating that a critical door alarm requires confirmation from the cloud.

6.6.3 Unique Instruction Encoding Structure

The known register event codes are as follows:

register name	Encoding range	Position Definition
SYS_INFO_REG	0x20000001(BIT0) / 0x20000002(BIT1)	system info
DOOR_INFO_REG	0x200100010x20010008(BIT0BIT3)	Door Body Information
DOOR_ERROR_REG	0x20210001(BIT0) / 0x20210002(BIT1)	Door body error

register name	Encoding range	Position Definition
DOOR_EEROR_REG (spelled this way)	—	Page error (suspected duplication or spelling variant)
WS_ERROR_REG	0x202700010x20270004(BIT0BIT2)	Meteorological station error
DOOR_ALERT_REG	0x204100010x20410008(BIT0BIT3)	Critical Door Body Alarm

The encoding scheme can be interpreted as follows: 0x20 + module number (00 = system / 01 = gateway / 27 = weather station WS / 41 = gateway alarm) + category (00 = INFO / 20 = ERROR / 40 = ALERT) + bit sequence number. Although no explicit encoding rule document has been provided for this scheme, it can be inferred from the known encodings. When parsing custom events, integrators may refer to this scheme, but should ultimately rely on the actual register mapping table.

6.6.4 Full-awareness state reporting

The hangar reports the following dimensions in two modes: OSD (fixed-frequency 0.5 Hz) and state (during state changes):

dimension	Properties/Registers	explain
Transmission status	cover_state / putter_state / roller status / centering rod status / limit switch	Full-process status reporting
ambient condition	temperature / humidity / environment_temperature / wind_speed / rainfall	Temperature and humidity inside and outside the cabin; air velocity; precipitation
Electrical status	power_state / charging voltage and current / battery temperature and state of charge / maximum and minimum voltage	End-to-End Power Supply and Charging
Positioning status	GPS_state（state/latitude/longitude）	GPS status bits: BIT0 online/offline, BIT3-BIT1 positioning mode, BIT4 east/west longitude, BIT5 north/south latitude
Communication status	Online status of each module	IO module / weather station / remote controller, etc.
safe state	emergency_stop_state / smoke_value	Emergency Stop and Smoke
device status	firmware_version / firmware_upgrade_status / binding status / version number	Firmware and Identity
Drone status	drone_in_dock / drone_state / rc_state / drone_charge_state	In the cabin / Power on/off / Remote control / Charging

FAQ: Key Considerations for Customization. Category 9 mentions "status reporting (whether it is full-sense perception)," indicating that "full-sense perception" is a key marketing term for HEISHA. Based on the attribute list above, HEISHA indeed provides status reporting across eight dimensions—transmission, environment, electrical systems, positioning, communications, safety, equipment, and UAVs — which represents a relatively comprehensive perception architecture among comparable products.

6.6.5 Acoustic and visual alarm

RGBtri coloured lantern:

The three-color lamp register has a total of 16 command codes:

command code	meaning
1	red lantern
2	green light
3	blue light
4	yellow light
5	close
9	Red Flash
10	Green light flashing
11	Blue light flashing
12	Yellow light flashing
13	Red Flash Mob
14	Green Light Flash Mob
15	Blue Light Pop-up
16	Yellow Light Flash

Register status word: 0x0100 = red light / 0x0200 = green light / 0x0400 = blue light / 0x0800 = yellow light / 0x0001 = flashing red light / 0x0002 = flashing green light / 0x0004 = flashing blue light / 0x0008 = flashing yellow light / 0x0011 = fast flashing red light / 0x0012 = fast flashing green light / 0x0014 = fast flashing blue light / 0x0018 = fast flashing yellow light

Acoustic and visual alarm event:

Events that trigger the audible and visual alarm include: -Abnormal opening of the rain cover-Completion of the drone's takeoff preparation-Drone takeoff-Drone return

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6.7 Local Control and Edge Computing

6.7.1 T100 Control Board

Main controller PCB/Main controller board model: T100 (T100 is indicated on D80/D135/D200/DCAP)

Operating System: Embedded Linux

Programming language: C

Core capability: The integrated command program runs locally, allowing batch processing commands to continue executing even when offline.

6.7.2 Five Comprehensive Instructions

The T100 comprehensive instruction set provides the following five operations:

instruct	Method	explain
One-Click Backup Flight	pre_takeoff	Automatically execute the entire standby flight process
Disable one-click standby	—	Terminate the standby flight procedure
Pre-flight confirmation	—	Manual confirmation continued (person remains in the loop)
One-touch charging	after_landing	Automatic charging process after landing
Disable one-touch charging	—	Terminate charging process

6.7.3 One-click flight preparation: 16 steps, step_key, complete workflow

The step_key sequence for one-click standby is as follows:

check_rainfall → confirm_rainfall → check_wind → confirm_wind →

close_putter → turn_on_rc → open_cover → open_drone →

free_putter → check_pilot → check_battery → confirm_battery →

check_gps → confirm_gps → check_rtk → confirm_rtk

The pairing of check_xxx and confirm_xxx embodies the "Human-in-the-Loop" principle: -check_rainfall: automatically checks rainfall; -confirm_rainfall: if rainfall exceeds the threshold, the process is paused and the operator is asked for manual confirmation before proceeding; -the same principle applies to the monitoring of wind speed, power consumption, GPS, and RTK.

This means that, in unattended scenarios, if environmental conditions exceed the specified limits and no one confirms them, the standby flight procedure will be suspended and will remain pending. The integrator needs to implement a confirmation interface on the cloud platform or on a local HMI.

6.7.4 Optional edge computing extension

The optional expansion configuration list for the D90 includes a "local edge computing server."

The "ZIGLER in-vehicle embedded solution" incorporates an edge computing unit that can process aerial photography data in real time and synchronously transmit it back

to the command center.

The introduction of edge computing servers means that edge devices can serve not only as execution terminals but also handle computationally intensive tasks such as data preprocessing and AI inference, thereby reducing reliance on cloud bandwidth and latency. This is particularly important for scenarios such as video analytics and real-time object detection.

6.8 Human–Computer Interaction and Debugging

6.8.1 Touchscreen

The following products feature a 4.3-inch touchscreen as their human-machine interface: -DCAP-D135-D200

The packaging list for the D80 and D135 includes "Touchscreen-Controlled PDA (458 Control)."

6.8.2 PDAdebugging aid

Complete technical specifications for the PDA debugging tool:

project	specifications
design criteria	Medical-grade (Medical-grade> Industrial-grade> Commercial-grade> Consumer-grade)
processor	400M SOC
form of a written or printed character	Built-in vector anti-aliasing fonts; supports ASCII/GBK/UNICODE
multi-media	JPEG image compression, MP3 audio, and GIF animation playback
Configuration controls	Buttons, text, drop-down menus, progress bars, gauges, curves, sliders, selections, icons, animations, data logging, audio, RTC, QR codes
multilingual	Support one-click switching between any language worldwide
script	Supports Lua script programming
Testing and Certification	Medical-grade testing for EMI radiation, high and low temperatures, microwave interference, coil interference, burst pulses, and other conditions
power dissipation	Minimum backlight + processor at full speed ≈0.4 W; sleep mode ≈0.17 W
upgrade	Supports remote image/firmware updates, incremental updates, and in-flight updates.
Panel brand	BOE/ Innolux/ Hancai (subject to available market supply)

The configuration control capabilities of PDA debugging tools are of significant importance for field debugging: -Progress bars/instrument/curve controls → enable real-time display of charging progress, temperature changes, and voltage curves-LUA scripts

→ allow custom logic to be executed within the PDA, reducing the communication frequency with the control board-Medical-grade testing → ensure stable operation even in industrial environments with severe electromagnetic interference-In-service upgrades → enable PDA firmware updates without requiring a system shutdown, thereby reducing on-site maintenance windows

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6.9 Software product portfolio and secondary development capabilities

6.9.1 Source Code Package Product Catalog

The following is the product catalog for the Heisha Software source code package, reproduced verbatim:

classify	DJI Flight Control	MAVLINK open-source flight controller (PX4, ArduPilot, INAV)	Third-party encapsulated flight control
HEISHA CLOUD SOFTWARE	HSC-MSDK-DJI	HSC-MSDK-MAV	Accept customization
HEISHA HSC (based on DJI PSDK)	HSC-PSDK-DJI	N/A	Accept customization
Scheduling Software (Android version)	DNEST-APP-DJI	DNEST-APP-MAV	Accept customization
Scheduling Software (WEB Version)	DNEST-WEB-DJI	DNEST-WEB-MAV	Accept customization
Precise Return to Library – DJI M4E/MAVIC3E	QRPL-M4E	N/A	Accept customization
Precise Return to the Library – DJI MINI	QRPL-Mini	N/A	Accept customization
Hangar Remote Operations and Maintenance Platform	Q100 V2.0		

6.9.2 HSC: InCloud Intermediate Software

Positioning and Features of HSC (HEISHA CLOUD):

Deployment format: Android APK or Linux application, running on a remote-control Android system or a local desktop computer

Core functionality: Parse drone flight-control commands or MSDK and package them into an MQTT IoT model

Architectural significance: "All aircraft can share a single API, and all types of unmanned aerial vehicles can share a single API; the only difference lies in the extent of functional completeness."

Delivery method: Direct delivery of source code

HSC Cloud Access Function Set (12 items):

order number	function
1	Aircraft startup progress
2	Aircraft shutdown progress
3	Remote control activation progress (exclusive to HEISHA)
4	Remote control shutdown progress (exclusive to HEISHA)
5	Cabin cover closure progress
6	Open the hatch progress
7	Pusher closure progress
8	Pushrod deployment progress
9	Open charging progress
10	Turn off charging progress
11	Set the air conditioning temperature
12	Alarm early-warning function

HSC-DJI Basic Feature Set (35 items):

Includes: setting the camera mode; starting photography; starting/stopping video recording; formatting storage; rotating the gimbal via angle mode; resetting the gimbal; autonomous takeoff/landing; stopping autonomous landing; intelligent return flight/stop; logging in/out to the DJI account; enabling/disabling the simulator; enabling/stopping live streaming (RTMP); configuring live-streaming video quality; uploading/starting/pausing/restoring/stopping flight missions; enabling/disabling virtual joystick mode; virtual joystick advanced mode and parameters; enabling/ending/updating mission targets; and the RTK module switch/data source/customized parameters/network RTK service.

6.9.3 Basic Coverage Analysis

metric	numeric value
Total number of MSDK functions	312 items
Basic Version Analysis	42 items
fraction of coverage	13.5%

The basic version covers approximately 13.5% of the MSDK functionality and is positioned as "flight-capable" rather than "operational": basic flight-control functions, such as manual flight and route-based flight, have been encapsulated; task scheduling, result processing, and industry payload control require customers to extend these capabilities themselves or supplement them through customization. When selecting a solution, the coverage should be verified against the project's functional requirements list to avoid estimating the workload based on the expectation of a "complete SDK."

This coverage figure is critical for integrators in assessing the workload required for secondary development. The basic version covers core flight control and flight-path mission functions; however, features such as perception-based obstacle avoidance, multimedia file management, payload management, firmware updates, and flight restriction lifting are not included. Integrators should assess whether expansion is necessary based on their specific business requirements and allocate appropriate development and joint debugging time into their project schedules.

6.9.4 DNEST: One-Stop Task Management Platform

Core features of DNEST:

project	explain
fixed position	One-stop UAV mission management cloud platform
function	Cloud-based real-time live streaming, manual flight, KML route-based flight, route planning, and unattended operations
Delivery Method	**Direct delivery of source code**
Self-deployment	Customers can deploy their own servers with unlimited storage space.
data security	Strictly protect customers' private data
Visual aids	Supports visual-assisted regression and uploading of 2K source files
APPend	Android 11 or later smartphones/tablets/Android TV
WEBend	Google Chrome is recommended
MQTTaddress	APP endpoint: tcp://server:1883; WEB endpoint: ws://server:8083/mqtt
functional module	Total: 40 items

DNEST compatible versions: MAVIC3E/T, M4E/T, M350, M400, KDW (open-source drones).

6.9.5 DNEST MQTT Access Specification

DNEST's MQTT access addresses: -App side: tcp://server:1883-Web side: ws://server:8083/mqtt

These two ports correspond to different transport protocols: -TCP 1883: standard MQTT over TCP, suitable for direct connection to native apps-WebSocket 8083: MQTT over WebSocket, suitable for web applications running in browsers

When an integrator builds its own platform or deploys DNEST, it must open the MQTT and WebSocket ports through the firewall; if TLS is used, the corresponding MQTTS and WSS ports must be opened. Certificate and mutual authentication configurations should be set according to the deployment environment, while port and encryption options should follow the deployment manual.

6.9.6 Version iteration activity

The version update records in the product introduction documentation provide insight into the iterative activity of Heisha Software and its documentation:

API documentation: the full version was first officially released on 2025-05-01; the latest version was released on 2026-06-22, with approximately 30 version entries.

Product documentation: from 2025-05-25 to 2026-10-22, with a total of 27 version records

Over the past approximately 17 months, the API documentation has undergone around 30 version updates, averaging roughly one update every 17 days. This iteration frequency indicates that: -The product is continuously evolving, and its interfaces are being steadily supplemented and refined; -When integrating with the API, integrators should pay attention to version compatibility; it is recommended that a version-numbering mechanism be used to manage integration code; -New features are being added relatively quickly, and coverage of the basic version may increase over time.

6.9.7 Analysis of Delivery Forms

Delivery format	product	Significance for integrators
Source Code Delivery	HSC、DNEST	Deeply customizable, self-maintainable, and free from vendor lock-in
AAR Binary Delivery	Vision SDK	Integrated into the proprietary app; internal logic cannot be modified.
Accept customization	Third-party flight control and special functions	Development on demand; the timeline and cost require separate assessment.
standard product	Q100 V2.0	An out-of-the-box remote operations and maintenance platform

"Direct delivery of source code" is a key strategy that distinguishes Heisha from many competing products. For integrators, this means: -Self-contained and controllable: No reliance on Heisha for subsequent feature extensions or maintenance; -Deep integration: HSC/DNEST code can be embedded into the customer's own platform, enabling seamless integration; -Learning curve: The team must possess the appropriate development capabilities (Android/Java for HSC-MSDK, Web for DNEST-WEB); -Scope of responsibility: Once the source code has been delivered, bugs resulting from modifications made by the customer are not covered by Heisha's after-sales service.

It is recommended that integrators, when evaluating whether to purchase source code, take into comprehensive consideration the compatibility of the source code with their own team's technology stack as well as the long-term maintenance costs.

6.10 Intelligent Selection Checklist

Based on FAQ "Key Considerations for Customizing HEISHA Machine Libraries," Categories 4 (intelligent components), 7 (communications), and 9 (interfaces and documentation) have been compiled into a selectable configuration table:

Intelligent Component Selection

Requirements	option	check	remarks
Number of surveillance cameras	□ 1 □ 2 □ Others___		Configured separately inside and outside the warehouse
Lens mounting position	□ Inside the warehouse □ Outside the warehouse □ Both		—
Camera angle requirements	□ Wide-angle □ Narrow-angle □ Adjustable		Effective range: within 10 m (specifications)
Weather sensor	□ Six key elements □ Simplified configuration (wind speed + rainfall) □ Not required		Six parameters: temperature and humidity / wind speed / wind direction / precipitation / atmospheric pressure / irradiance
Acoustic and visual alarm	□ Required □ Not required		Flicker / flash burst / long illumination available
RGB status lamp	□ Required □ Not required		16 colors / flashing modes
Temperature and humidity sensor	□ Inside the cabin □ Outside the cabin □ Both		—
fire-fighting equipment	□ Fire extinguisher □ Others ___ □ Not required		The linkage logic shall be determined in accordance with the project fire protection plan (see 6.4.4).
AIvisual performance	□ Precise QR landing □ Off-site AB-point landing □ Others___		Supports integration only for Android app platforms

Communication Equipment Selection

Requirements	option	check	remarks
Primary communication method	□ 4G □ 5G □ RJ45 Ethernet □ STARLINK □ Private Network		—
Redundant communication	□ Required □ Not required		Redundant communication mode switching
Signal strength reporting	□ Required □ Not required		Used for remote assessment of communication quality
MQTT Broker	□ Self-built □ Using DNEST		tcp://server:1883 or ws://server:8083/mqtt

Interface and Documentation Selection

Requirements	option	check	remarks
Interface Protocol	□ MQTT □ MODBUS RTU □ MODBUS TCP		D90 supports three types

Requirements	option	check	remarks
Video streaming	□ RTMP □ RTSP □ Not required		Millisecond-level latency
State reporting completeness	□ Full Awareness □ On-Demand Tailoring		"Full Sensing" is the key selling point term for HEISHA.
APID	□ Required □ Already Available		Heisha API Documentation
HSC source code	□ Purchase □ Not required		Direct delivery of source code
DNEST source code	□ Purchase □ Not required □ Build your own platform		Direct delivery of source code
HSC operating computer	□ Self-provided □ Provided by Heisha		Android operating system or Linux microcomputer

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Charpter 7 Interfaces and Development Protocols

This chapter serves as the most essential technical reference for integrators and developers using the HEISHA Drone Garage platform. Through a standardized MQTT object model protocol, the HEISHA Drone Garage platform exposes its full hardware capabilities externally, enabling cloud-based business software to handle all integration tasks — including garage control, drone scheduling, and status monitoring — without needing to concern itself with underlying flight control or electromechanical details. The following content is based on the *HEISHA Cloud API* documentation (latest version: 2026-06-22) and the *HEISHA Object Model and Register Mapping Table* v1.0 (2026.9.13); all field names, method names, and enum values are cited verbatim, including any spelling variations.

7.1 Overview of the Communication Architecture

7.1.1 Layering and Roles

The Heisha Ruyun framework adopts a three-tier role model:

role	explain	Typical entity
Cloud	Use a business cloud platform or a self-deployed server for the customer to subscribe to device-reported messages and issue control commands.	Customer backend, DNEST Cloud Platform
Gateway device (Gateway)	Devices that establish a persistent connection directly with the MQTT Broker support device management and proxy-based sub-device access.	T100 central control panel (hangar), remote control
Sub-device	Devices that access the cloud via a gateway device proxy do not connect directly to the Broker.	unmanned aerial vehicle

The gateway device is responsible for: -Establishing a persistent MQTT connection

with the Broker; -Reporting the topology relationships between itself and its child devices; -Forwarding OSD/state/events data from child devices; -Receiving and executing cloud-delivered services/property-set commands.

7.1.2 MQTT Protocol Versions and Topic Prefix System

This agreement is based on the MQTT 3.11 standard (see the "Introduction to MQTT" section). Topics are divided into two major functional prefix categories:

class	Topicprefix	use
Basic Topics	sys/	General functions such as equipment registration and lifecycle status updates
Physical Model Class Topic	thing/	Functional interaction among object models such as Property, Service, and Event

In addition, energy storage power supplies use the independent prefix thing/power/ (see Section 7.8 for details).

7.1.3 Complete Topic List

The table below lists all 14 Topic categories. {gateway_sn} denotes the SN of the gateway device, while {device_sn} denotes the SN of the device to which the asset model attribute belongs.

Topictemplet	direction	use	Push Mode / Trigger mode
thing/product/{device_sn}/osd	Equipment → Cloud	Fixed-frequency device reporting properties (Properties)	pushMode=0,0.5Hz fixed frequency
thing/product/{device_sn}/state	Equipment → Cloud	Device property reporting on demand	pushMode=1: push immediately upon a state change
thing/product/{gateway_sn}/services	Cloud → Device	The cloud sends a service call to the device	Event Trigger
thing/product/{gateway_sn}/services_reply	Equipment → Cloud	Device response to the service processing result	respond
thing/product/{gateway_sn}/events	Equipment → Cloud	Events requiring attention and handling in equipment reporting	Event Trigger
thing/product/{gateway_sn}/events_reply	Cloud → Device	Cloud response to device events	respond
thing/product/{gateway_sn}/requests	Equipment → Cloud	The device requests information from the cloud (e.g., binding status).	Event Trigger
thing/product/{gateway_sn}/requests_reply	Cloud → Device	Cloud response to device requests	respond
sys/product/{gateway_sn}/status	Equipment → Cloud	Equipment commissioning and decommissioning, topology updates	Event Trigger
sys/product/{gateway_sn}/status_reply	Cloud → Device	Platform response to status	respond
thing/product/{gateway_sn}/proper	Cloud → Device	Set read/write access	Event Trigger

Topictemplet	direction	use	Push Mode / Trigger mode
ty/set		(accessMode=rw)	
thing/product/{gateway_sn}/property/set_reply	Equipment → Cloud	Response to attribute settings	respond
thing/product/{gateway_sn}/drc/up	Equipment → Cloud	DRC Virtual Joystick Protocol Upstream	actual time
thing/product/{gateway_sn}/drc/down	Cloud → Device	DRC Virtual Joystick Protocol Downstream	actual time

The QoS levels for each Topic are not defined individually in the protocol documentation. During integration, the following default values may be adopted and hard-coded into the interface contract: for control Topics (service/events), set QoS to 1 (at least once) to ensure that no commands or responses are lost; for status Topics (OSD/state), QoS may be set to 0 to reduce bandwidth and storage overhead. The actual values should be confirmed with HEISHA.

7.1.4 Public Field Definition

All MQTT messages (payloads) share the following common fields:

field	type	Required	meaning
tid	text (UUID)	yes	Transaction UUID. Represents a simple message exchange (e.g., a request + response) and is used to address issues related to transaction concurrency and message matching.
bid	text (UUID)	yes	Business (Business) UUID. Some functions cannot be completed in a single communication; they encompass all interactions occurring over a period of time. Business operations consist of multiple atomic transactions, which are used to address issues related to high concurrency and repeated requests within the business context.
timestamp	int	yes	Message send time: 13-digit millisecond-level Unix timestamp
gateway	text	yes	The serial number of the gateway device that sent this message
data	object	yes	Specific details of the message

The three message types—services, events, and requests—also include an additional method field that identifies the specific service/event/request method name.

7.1.5 Differences between tid and bid and their handling in concurrency

This is the most easily confused concept in the integration process; it is essential to understand it:

tid (transaction ID): Corresponds to an atomic communication in a "request – response" cycle. For example, when a services call is issued and a corresponding services_reply is returned, both have the same tid. Each new request generates a new tid.

bid (Business ID): Corresponds to a complete business process that spans multiple communications. For example, during one-click flight preparation, the process—from the issuance of pre_takeoff, through progress reporting across multiple events, to completion via the final services_reply—shares the same bid throughout.

Recommendations for integration: -Use tid to pair requests with responses; -Use bid to track the overall state of a long-running process; -The cloud should maintain a state machine at the bid level to avoid concurrency conflicts within the same bid; -Both tid and bid should be in UUID format and can be generated independently by the sender.

7.1.6 Data push mechanism (pushMode)

pushMode	Transmission mechanism	transmission frequency	suitTopic
0	Active fixed-frequency push notifications on the device side	0.5 Hz (once every 2 seconds)	thing/product/{device_sn}/osd
1	Push immediately upon state change	Variable frequency; whenever there is a change, it is triggered.	thing/product/{device_sn}/state
2	No proactive pushing; data is retrieved proactively by the server.	as required	Suitable for on-demand queries for state classes

Implementation recommendations: For real-time monitoring panels, subscribing to the osd Topic provides full status updates with a 2-second refresh rate; for low-frequency events such as alerts and firmware updates, subscribing to the state Topic enables you to receive instant notifications whenever a change occurs.

7.1.7 System Architecture and MQTT Links

Figure 7-1 System Architecture and MQTT Link

Figure 7-1 System Architecture and MQTT Link

Figure 7-1 System Architecture and MQTT Link

The diagram illustrates the connectivity between the hangar (T100 central control board), remote controller, and drone, as well as their connections to the MQTT Broker and the cloud. The hangar and remote controller serve as gateway devices and connect directly to the Broker, while the drone functions as a subordinate device and connects via a gateway proxy.

7.2 Gateway and Sub-device Topology Management

7.2.1 device type

role	device type	explain
Gateway device	Hangar (T100 Central Control Panel)	Local control board for D-series / T-series hangars
Gateway device	telecontroller	Run HSC software using a DJI remote control or an external microcomputer
Sub-device	unmanned aerial vehicle	Access via a gateway proxy; no direct connection to the Broker

7.2.2 Deployment Process (update_topo)

After the gateway device is powered on, it reports topology information via the sys/product/{gateway_sn}/status topic, with method set to update_topo. The message contains the gateway's own information and a list of the sub-devices it manages.

message structure:

field	type	explain
data.type	int	Gateway Device Type Code
data.sub_type	int	Gateway device subtypes
data.device_secret	text	Device Key
data.nonce	text	random number
data.version	int	version number
data.sub_devices	array	Sub-device List
data.sub_devices[].sn	text	Sub-device serial number
data.sub_devices[].type	int	Sub-device type code
data.sub_devices[].sub_type	int	Sub-device Sub-type
data.sub_devices[].index	text	Sub-device index identifier
data.sub_devices[].device_secret	text	Sub-device key
data.sub_devices[].nonce	text	Sub-device random number
data.sub_devices[].version	int	Sub-device version number

Complete JSON example (gateway device + child devices connected):


```
{
"tid": "xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxx",
"bid": "xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxx",
"method": "update_topo",
"timestamp": 1234567890123,
"data": {
"type": 98,
"sub_type": 0,
```

```
"device_secret": "secret",
"nonce": "nonce",
"version": 1,
"sub_devices": [
 {
"sn": "drone001",
"type": 116,
"sub_type": 0,
"index": "A",
"device_secret": "secret",
"nonce": "nonce",
"version": 1
 }
 ]
 }
}
```


7.2.3 Offline workflow

When a sub-device is taken offline, the update_topo method is also used, but the sub_devices array is empty:


```
{
"tid": "xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxx",
"bid": "xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxx",
"method": "update_topo",
"timestamp": 1234567890123,
"data": {
"type": 98,
"sub_type": 0,
"device_secret": "secret",
"nonce": "nonce",
```

"version": 1,

"sub_devices": []

}

}

7.2.4 Topological change sequence

sequenceDiagram

Participant GW as gateway device (control cabin/remote controller)

participant BR as MQTT Broker

CL participant as a cloud-based solution

GW->>BR: CONNECT

BR-->>GW: CONNACK

GW->>BR: SUBSCRIBE sys/product/{gw_sn}/status_reply

GW->>BR: PUBLISH sys/product/{gw_sn}/status
method=update_topo, sub_devices=[...]

BR ->>CL: Forward status message

CL->>BR: PUBLISH sys/product/{gw_sn}/status_reply
result=0

BR->>GW: Forward status_reply

Notes on GW and CL: when a sub-device goes offline

GW->>BR: PUBLISH sys/product/{gw_sn}/status
method=update_topo, sub_devices=[]

BR->>CL: Forward status message

CL->>BR: PUBLISH sys/product/{gw_sn}/status_reply
result=0

Integration recommendation: After receiving update_topo, the cloud service should respond with status_reply within 5 seconds (result=0 indicates success); otherwise, the device may resend the request.

7.3 Physical Model and Attribute Reporting

7.3.1 The difference between OSD and state

dimension	OSD（pushMode=0）	state（pushMode=1）
Topic	thing/product/{device_sn}/osd	thing/product/{device_sn}/state
Push frequency	0.5 Hz fixed frequency (every 2 seconds)	Push immediately upon state change
applicable scene	Real-time telemetry of continuously varying parameters such as temperature, humidity, and voltage	Discrete change attributes such as firmware version and upgrade status
data integrity	Each push contains the complete set of OSD fields.	Only push fields that have changed

7.3.2 D-Series Hangar Object Model Attribute Classification Table

The following is the physical model attribute list for the D-series hangar (in-house developed by Heisha):

classify	field name	type	Unit/Value Range	Access Mode	pushMode	explain
environment	temperature	float	°C	r	0	Cabin temperature
environment	humidity	float	%RH (0~100, step 0.1)	r	0	Cabin humidity
environment	environment_temperature	float	°C	r	0	ambient temperature
environment	wind_speed	float	m/s	r	0	wind speed
environment	rainfall	enum_int	0: No rain 1: Light rain 2: Moderate rain 3: Heavy rain	r	0	rainfall
machinery	cover_state	enum_int	0: Closed 1: Open 2: Semi-open 3: Abnormal hood status 9: Unknown	r	0	Hood status
machinery	putter_state	enum_int	0: Off 1: On 2: Half-on 3: Pusher abnormal state 9: Unknown	r	0	Pusher state
machinery	hatchway_state	enum_int	0: Unknown 1: Off 2: On 4: On (intermediate) 5: Off (intermediate) 6: Fault	r	0	Return-to-center window state
machinery	rotate_motor_state	int	0: Off 1: On	r	0	State of the rotary motor on the return-centerboard rotary table
machinery	pulp_motor_state	int	0: Unknown 1: Position 1 2: Position 2 3: Position 3 4: Position 4 5: In Progress 6: Error	r	0	Pulp collection motor status
charge	drone_charge_state	struct	—	r	0	Aircraft charging status
charge	»capacity_percent	int	0~100	r	0	Battery level percentage

classify	field name	type	Unit/Value Range	Access Mode	pushMode	explain
charge	»state	enum_int	0: Idle 1: Charging	r	0	Charging status
charge	discharge_state	int	0: Normal; 1: Discharging	r	0	Battery discharge status
source	power_state	float	AC_U/AC_MAX_U/AC_MIN_U	r	0	Main power supply status
source	emergency_stop_state	enum_int	0: Off 1: On	r	0	Emergency stop button status
air-conditioning	air_conditioner	struct	—	r	0	Air conditioner operating status
air-conditioning	»air_conditioner_state	enum_int	0: Idle 1: Cooling 2: Heating 3: Dehumidification 4: Cooling Exit 5: Heating Exit 6: Dehumidification Exit 7: Cooling Preparation 8: Heating Preparation 9: Dehumidification Preparation	r	0	Air conditioner status
sensor	smoke_value	float	—	r	0	smoke transducer
fixed position	GPS_state	struct	—	r	0	GPS state
fixed position	»state	int	0: Off 1: On	r	0	GPSswitch
fixed position	»latitude	double	—	r	0	latitude
fixed position	»longitude	double	—	r	0	longitude
equipment	firmware_version	text	max 64 chars	r	1	Firmware version
equipment	firmware_upgrade_status	enum_int	0: Not upgraded 1: Upgrading	r	1	Firmware update status
equipment	drone_in_dock	int	0: Extracorporeal (inorganic) 1: Intracorporeal (organic)	r	0	Is the aircraft inside the cabin?
equipment	rc_state	int	0: Off 1: On	r	0	Remote control status
equipment	drone_state	int	0: Shut down 1: Power on 2: Unknown	r	0	Drone status
special	pitot_tube_state	int	0: Off 1: On	r	0	Air velocity tube blower fan
special	tethering	struct	—	r	0	Fishing assembly
special	»state	int	0: Off 1: On	r	0	Fishing condition
special	»level	int	0: Stop; 1: 1st gear; 2: 2nd gear	r	0	Fishing line anchor point

Note: The "special" designation applies only to specific customized models (e.g.,

tilt-up drones, airports equipped with discharge resistors, etc.).

7.3.3 Differentiated attributes of the T-series hangars

The Pengchao Logistics Terminal Cabinet series adds the following features to the D series:

field name	type	explain
environment_humidity	float	Environmental humidity (%RH); the D series does not have this field
wind_direction	float	Wind direction (degrees; 0 = due north, 90 = due east); this field is not available in the D series.
locker_type	enum_int	Cabinet type: 0 = multi-door cabinet, 1 = single-door cabinet
locker_total	int	Number of lockers (1–32)
access_door_state	enum_int	Cargo storage/withdrawal gate status: 0: Unknown; 1: Closed; 2: Open; 4: Opening; 5: Closing; 6: Fault (valid when locker_type==1)
locker_door_state	enum_int_array[32]	Container door status array, length 32, representing the status of storage container doors No.1–32 (valid when locker_type==0)
locker_state	enum_int_array[32]	Container status array, length 32:0: unavailable; 1: empty; 2: full
machine_arm	struct	State of the three-axis robotic arm (see below for details)
task_in_progress	bool	Are there any tasks currently being executed?

machine_arm substructure:

field name	type	explain
working_state	enum_int	0: Unknown 1: Resetting 2: Reset complete 3: Loading 4: Loading complete 5: Receiving 6: Receiving complete 7: Unloading 8: Unloading complete 9: Picking 10: Picking complete 11: Storing 12: Storing complete 32: Fault
working_target_locker	int	Work target container number (1~locker_total)
reach_state	enum_int	Extension axis: 0: Unknown; 1: Fully retracted; 2: Fully extended; 5: Actuation in progress; 6: Fault
pan_state	enum_int	Translation axis: 0: Unknown; 1: Stops at column 1; 2: Stops at column 2; 3: Stops at column 3; 15: Action in execution; 16: Fault
tilt_state	enum_int	Tilt axis: 0: Unknown; 1: Stops at row 1; 2: Stops at row 2; 3: Stops at row 3; 14: Stops at the small-window position; 15: Action in progress; 16: Fault
tilt_is_lifted	bool	true: picked up; false: not picked up
column_count	int	Total number of storage lockers
line_count	int	Total number of lockers
pallet_state	enum_int	0: No cargo 1: Cargo available

Both cover_state and putter_state in the mapping table have two parallel enum definitions: for cover_state, the first set is {0: Unknown, 1: Off, 2: On, 4: On-Intermediate, 5: Off-Intermediate, 6: Fault}, and the second set is {0: Off, 1: On, 2: Semi-On, 9: Unknown, 4: On-Intermediate, 5: Off-Intermediate, 6: Fault}; putter_state likewise has two sets of definitions. The differences between the two sets focus on the four values 0, 1, 2, and 9. During interface integration, the actual message sent by the device shall

prevail: first, parse according to the second set, which includes "2: Semi-On"; when the semantics of 0 or 1 are unclear, perform cross-validation between the state and the mechanical status of the OSD; and after conducting value-by-value measurements during the joint debugging phase, the results shall be finalized in the interface contract. This section retains the parallel presentation; a unified terminology will be confirmed once the firmware and the mapping table are synchronized.

7.3.4 property/set: writable property mechanism

For attributes with accessMode = rw, the cloud can issue configuration commands via the thing/product/{gateway_sn}/property/set Topic. The currently writable attributes in the D series include air-conditioning temperature (max_temperature / min_temperature).

Configuration example (only 1 item can be modified at a time):


```
{
"bid": "xxxxxxxx-xxxx-xxxx",
"data": {
"max_temperature": 20
 },
"tid": "xxxxxxxx-xxxx-xxxx",
"timestamp": 1654070968655
}
```


Response example:


```
{
"bid": "xxxxxxxx-xxxx-xxxx",
"data": {
"some_property": {
"result": 0
 }
 },
"tid": "xxxxxxxx-xxxx-xxxx",
"timestamp": 1654070968655
```

```
}
```

Here, result: 0 = success, 1 = failure, 2 = timeout; other values refer to the error codes.

7.3.5 OSD Complete Message Example

The following is a complete JSON example reported by the D-series hangar OSD (quoted verbatim):


```
{
"tid": "eb04a53f-44b4-4766-a2c9-a7306c0ba804",
"bid": "c9d8c5d2-6ca1-4fc6-94ff-0663cb4ea0c3",
"timestamp": 1753966416907,
"gateway": "1XZEnemI85xy90iSeQNE",
"data": {
"air_conditioner": {
"air_conditioner_state": 0,
"max_temperature": 25.0,
"min_temperature": -100.0
},
"emergency_stop_state": 0,
"drone_charge_state": {
"state": 0,
"capacity_percent": 0
},
"humidity": 58.0,
"temperature": 31.8,
"environment_temperature": -100.0,
"wind_speed": 1.4,
"rainfall": 0,
"cover_state": 0,
"putter_state": 0,
```

```
"firmware_upgrade_status": 0,
"firmware_version": "v0.0.0",
"GPS_state": {
"state": 0,
"latitude": 0,
"longitude": 0
 },
"power_state": 0,
"smoke_value": 0,
"discharge_state": 0,
"pitot_tube_state": 0,
"rotate_motor_state": 0,
"drone_in_dock": 1,
"rc_state": 1,
"drone_state": 1,
"tethering": {
"state": 0,
"level": 0
 }
 }
}
```

7.4 Modbus Register Mapping (for MQTT protocol developers)

7.4.1 Meaning of Mapping Table Fields

"HEISHA Device Model and Register Mapping Table" v1.0 provides a correspondence between Modbus registers and MQTT device model fields for developers seeking a deeper understanding of underlying data encoding. The mapping table includes the following columns:

column name	explain

column name	explain
Associated Module	Hardware module assignments (gateway/roll/centering/charging 1/charging 2/air conditioner/meteorological station/RGB three-color lights/remote control base/I/O control/events)
Physical model type	0=OSD attribute; service/event/property=service/event/writable attribute
register description	The physical quantity or functional name associated with this register
Instruction content	For the service/event/property type, the specific operation name
MQTTfield name	Corresponds to the field name in the MQTT message
Parameter Details	Instruction parameter value
relative address	The index position of this field in the module data array
Unique command encoding	Hexadecimal encoding, used for the cmd or code fields of service/event
Position mask	BIT Bit Definition
Does a response need to be provided?	y/n
Model compatibility	Applicable hangar model
remarks	Numerical encoding rules, enumeration definitions, etc.

In the current version of the mapping table (v1.0, 2026.9.13), many columns — including relative addresses, MQTT field names, and parameter values — still contain placeholder values (represented by 0); full address assignments must be requested separately from Heisha. When referencing the mapping table below, only columns containing actual data are listed; placeholder columns are not included in parsing.

7.4.2 Module Partitioning

The mapping table covers 11 hardware modules:

module	major function
gateway	Device IP, GPS status/latitude/longitude/altitude, voltage, binding status, version number, one-touch standby flight/charging/reset/binding/unbinding, audible and visual alarms
expansion cylinder	Communication status, drum status, limit switches, temperature and humidity, tethering status, rain cover opening/closing/resetting/stopping, MCU reset, tethering high voltage, line-retraction position, RS485 configuration
Return to the center	Communication status, centering bar status, limit switches, centering tightening/release/stop/reset, window opening/closing/stop, slurry collection action
Charge 1/Charge 2	Online status, operating status (including battery health monitoring/power-on/off status fields), charging voltage/current, battery temperature/battery level/battery type, and charging/standby/power-on/off/power restoration commands
air-conditioning	Online status, four-channel temperature, PWM, relays (8-channel BIT), operating mode, WORKMODE (0–4), maximum/minimum temperature
weather station	Online status (BIT0–BIT3 correspond to temperature/humidity, rainfall, wind speed, and wind direction, respectively); temperature, humidity, rainfall, wind speed, and wind direction
RGBtri coloured lantern	Online status, light status (12 colors/flicker combinations), command code 1–16
Remote control base	Dual remote control online status / temperature and humidity / switch status / switch command

module	major function
I/Ocontrol	IO module online status, switch status (24V/12V/5V BIT), command code 1–16
event	Events in registers such as SYS_INFO_REG, DOOR_INFO_REG, DOOR_ERROR_REG, DOOR_EEROR_REG, WS_ERROR_REG, and DOOR_ALERT_REG

7.4.3 Numerical Scaling and Offset Rules

The following is the formula for decoding the raw values from Modbus registers into physical quantities. When parsing OSD data, developers must perform the inverse calculation:

physical quantity	Coding Rules (Notes)	Decoding Formula	unit
temperature	temperature ×10+1000	Physical value = (register value − 1000) / 10	°C
voltage	Voltage × 10	Physical value = register value / 10	V
humidity	Humidity × 10	Physical value = register value / 10	%RH
rainfall	Rainfall × 10	Physical value = register value / 10	mm
wind speed	Wind speed × 10	Physical value = register value / 10	m/s
wind direction	degree × 10	Physical value = register value / 10	degree
longitude and latitude	×10000000	Physical value = register value / 1,000,000,000	degree
height	×10	Physical value = register value / 10	Mi
Current	Current × 10	Physical value = register value / 10	A

Implementation note: The temperature encoding uses a +1000 offset to support negative temperature values. For example, a register value of 1250 corresponds to (1250 − 1000) / 10 = 25.0 °C; a register value of 750 corresponds to (750 − 1000) / 10 = −25.0 °C.

7.4.4 Key State Enum Table

Drum status

price	meaning
0x00	UNKNOWN
0x01	CLOSED
0x02	OPENED
0x03	ERROR (deprecated)
0x04	OPENING
0x05	CLOSING
0x06	FAULT

Return rod status

price	meaning
0x00	UNKNOWN
0x01	UNLOCKED
0x02	LOCKED
0x03	LOCKING_STEP1
0x04	LOCKING_STEP2
0x05	UNLOCKING
0x06	FAULT

Charging status (bitfield combination)

Bitfield	price	meaning
BIT0~BIT3	0x00	Not charged
BIT0~BIT3	0x01	Charging Preparation
BIT0~BIT3	0x02	Charging when powered off
BIT0~BIT3	0x03	Power-on charging
BIT0~BIT3	0x04	charge complete
BIT0~BIT3	0x08	hitch
BIT4~BIT5	0 (DRONE_DETECT_UNKNOWN)	unknown
BIT4~BIT5	1 (DRONE_DETECT_YES)	Battery detected
BIT4~BIT5	2 (DRONE_DETECT_NO)	No battery detected
BIT6~BIT7	0 (DRONE_ON_UNKNOWN)	unknown
BIT6~BIT7	1 (DRONE_ON_YES)	Power on the drone
BIT6~BIT7	2 (DRONE_ON_NO)	Unmanned system shutdown

Air Conditioner WORKMODE

price	meaning
0	Off mode
1	Strong Cooling Mode
2	Heating mode
3	Air-cooling mode
4	Constant Temperature Mode

RGB three-color LED command code

command code	meaning	condition code
1	red lantern	0x0100
2	green light	0x0200
3	blue light	0x0400
4	yellow light	0x0800
5	close	—
9	Red Flash	0x0001
10	Green light flashing	0x0002

command code	meaning	condition code
11	Blue light flashing	0x0004
12	Yellow light flashing	0x0008
13	Red Flash Mob	0x0011
14	Green Light Flash Mob	0x0012
15	Blue Light Pop-up	0x0014
16	Yellow Light Flash	0x0018

I/O control command codes

command code	meaning
1	24V On
2	24V Off
3	12V On
4	12V Off
5	5V On
6	5V Off
15	All open
16	All relevant

GPS Status Bit Definitions

position	meaning
BIT0	0: Offline 1: Online
BIT3~BIT1	0: Unpositioned; 1: SPS positioning; 2: Differential; 3: PPS
BIT4	0:东经 1:西经
BIT5	0:北纬 1:南纬

7.4.5 JSON Example (Word-for-Word Quote Mapping Table)

PROPERTY / OSD

modbus_Door_table:[1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0]

Value retrieval method: locate the relevant module → physical model type (OSD) → register description → MQTT field name → relative address (index bits) → remarks (value meaning).

SERVICE (service issuance)

{
"bid": "xxxxxxxx-xxxx-xxxx",
"data": {
"cmd": "0x80200002",

"param": 1
},
"tid": "xxxxxxxx-xxxx-xxxx",
"timestamp": 1654070968655,
"method": "modbus_cmd"
}

cmd is the unique command code; param contains the parameter values (this field is omitted if there are no parameters).

SERVICE (service_reply returns)

{
"tid": "xxxxxxxx-xxxx-xxxx",
"bid": "xxxxxxxx-xxxx-xxxx",
"timestamp": 1789577506000,
"method": "modbus_cmd",
"data": {
"result": 0,
"code": "0x80200002"
}
}

Determine which command's response it is based on the returned code.

EVENT （event_info / event_error / evet_alert）

event_info instance:

{
"tid": "xxxxxxxx-xxxx-xxxx",
"bid": "xxxxxxxx-xxxx-xxxx",
"timestamp": 1789577506000,
"method": "events_info",
"data": {
"message": "msg",

"code": "0x20000001"

}

}

event_error / evet_alert: How to retrieve:

1. As above, using the info data, change the method field to event_error or evet_alert (note: the spelling is evet_alert);

2. Proactively retrieve: events_error_table: [0x20000001,...], events_alert_table: [0x20000001,...].

INFO event: When the register event flag is set, the event is reported once and then immediately cleared; it is not reported via OSD. ERROR and ALERT events are reported at a fixed frequency together with reports from all modules.

7.5 Service Calls and Hardware Control Commands

7.5.1 SERVICE + EVENT Pairing and Interaction Model

HEISHA's hardware control commands employ a SERVICE + EVENT pairing mode:

1. The cloud issues control commands (method + data) via the services Topic;

2. The device reports its execution progress (percent + step_key) in real time via the events Topic;

3. Once execution is complete, the device returns the final result (status) via the services_reply Topic.

sequenceDiagram

CL participant as a cloud-based solution

Participant GW as gateway device

participant HW as the hardware execution unit

CL->>GW: services: method=cover_open

GW->>HW: Start the lid-opening motor

GW->>CL: events: percent=30, step_key=open_cover, status=in_progress

GW->>CL: events: percent=70, step_key=open_cover, status=in_progress

HW-->>GW: Lid fully opened

GW->>CL: events: percent=100, step_key=open_cover, status=ok

GW->>CL: services_reply: result=0, status=ok

Completion 判定 rule: Execution is considered complete only when percent is 100 and status is ok.

7.5.2 Complete Instruction List

D Series General Instructions

classify	method	use	key parameter	Submit with progress updates
aerobat	drone_open	Power on the aircraft	not have	✔ (step_key: close_putter, open_drone)
aerobat	drone_close	Flight vehicle shutdown	not have	✔ (step_key: close_putter, close_drone)
telecontroller	rc_open	Remote control enabled (exclusive to HEISHA)	not have	✔ (step_key: turn_on_rc)
telecontroller	rc_close	Remote control turned off (exclusive to HEISHA)	not have	✔ (step_key: turn_off_rc)
hatch cover	cover_open	Open the hatch	not have	✔ (step_key: open_cover)
hatch cover	cover_close	Close the hatch	not have	✔ (step_key: close_cover)
push rod	putter_open	Push rod deployment	not have	✔ (step_key: free_putter)
push rod	putter_close	Push rod closed	not have	✔ (step_key: close_putter)
charge	charge_open	Turn on charging	not have	✔ (step_key: close_putter, close_drone, start_charge)

classify	method	use	key parameter	Submit with progress updates
charge	charge_close	Turn off charging	not have	✔ (step_key: stop_charge)
air-conditioning	set_air_conditioner_temperature	Set the air conditioning temperature	max_temperature / min_temperature	✘ (property/set)
report to the police	alarm_play	Alarm warning	audio_index: 1: Rain cover opened; 2: Takeoff preparation complete; 3: Takeoff; 4: Return	✘
discharge	drone_discharge_start	Initiate discharge (special customization)	not have	✘
discharge	drone_discharge_stop	Discharge stop (custom-made)	not have	✘
Velocity tube	wind_duct_fan_open	Turn on the wind-speed tube fan (special customization: vertical orientation)	not have	✘
Velocity tube	wind_duct_fan_close	Turn off the wind-speed tube fan (special customization: vertical orientation)	not have	✘
turntable	rotate_motor_stop	Return to neutral position (special customization: vertical lift)	not have	✘
turntable	rotate_motor_rotate	Rotate the return transfer disk to its position (special customization: vertical lift)	angle: -360~+360	✘
Slurry collection	collecting_pulp	Slurry collection (special customization)	code: 1 = Action 1, 2 = Action 2	✘
camera	camera_instruction	Install hangar cameras	camera_IP, rtp, flag (0: disabled; 1: enabled)	✘
Fishing line	tethering_open	Fishing line release (special customization)	not have	✘
Fishing line	tethering_close	Fishing line closure (special customization)	not have	✘
Fishing line	set_tethering_level	Set the level of the tethered collection line	Level: 0: Stop; 1: 1st gear; 2: 2nd gear	✘
Return Window	hatchway_open	Open the return and middle windows (special customization)	not have	✘
Return Window	hatchway_close	Close the return and middle windows (special customization)	not have	✘

T-series-specific instructions

method	use	key parameter	Submit with progress updates
access_door_open	Open the cargo loading/unloading door	not have	✔
access_door_close	Close the cargo loading/unloading doors	not have	✔
locker_door_open	Open the container door	locker_number: 1~locker_total	✔ (step_key: open_door)

method	use	key parameter	Submit with progress updates
start_loading	Start loading inventory	locker_number: 1~locker_total	✔ (percent is the step number 0–11)
stop_unloading	Stop loading	not have	✘
start_unloading	Start unloading	Cargo container number, target slot number	✔
start_pickup	Pickup	locker_number or from_line+from_column	✔
start_dropdown	release cargo	Gate number, opening height	✔
start_storageing	stock	Cargo container number, source grid opening number	✔
start_prepare_landing_pad	Prepare the landing platform	Platform ID: timeout during positioning	✔
set_task_in_progress	Set a flag during task execution	No parameters; only set the flag bit.	✘

7.5.3 Standardized Progress Reporting Structure

For all instructions that report progress, the output structure in their events messages is uniformly defined as follows:

field	type	explain
output.status	enum_string	canceled: canceled or terminated / failed: failed / in_progress: in progress / ok: successfully executed / paused: paused / rejected: rejected / sent: sent / timeout: timeout
output.progress.percent	int	Progress percentage: 0–100
output.progress.step_key	enum_string	Current execution step identifier

7.5.4 One-click pre_takeoff: complete step_key chain

One-key standby flight is a core feature of the T100 comprehensive command set; it runs on the aircraft's local control panel and can continue to execute even when the network connection is interrupted. Its step_key sequence is as follows:

order number	step_key	meaning	explain
1	check_rainfall	Checking rainfall	Automatic detection of rainfall data from meteorological stations
2	confirm_rainall	Rainfall has exceeded the standard; we are awaiting confirmation on whether to proceed.	Pause when the limit is exceeded; wait for the cloud to send pre_takeoff_confirm
3	check_wind	Wind speed is currently being measured	Automatic detection of wind speed data from meteorological stations

order number	step_key	meaning	explain
4	confirm_wind	Wind speeds exceed the limit; we are awaiting confirmation on whether to proceed.	Pause when exceeding the limit and wait for cloud-based confirmation.
5	close_putter	Charging pole tightening in progress	Retract the pusher rod to the locking position
6	turn_on_rc	Remote control being powered on	Power on remotely via the remote control base
7	open_cover	Rain cover is being opened	Open the drive drum motor cover
8	open_drone	The aircraft is being powered on	Send a drone startup command
9	free_putter	The charging dock is currently being released.	Release the push rod to the extended position
10	check_pilot	Checking Pilot's online status	Confirm that the remote control app is ready
11	check_battery	Checking the aircraft's battery capacity	Read the drone battery SOC
12	confirm_battery	Battery level is too low; please wait for confirmation on whether to continue.	Pause when below the threshold
13	check_gps	GPS check in progress	Detect GPS positioning quality
14	confirm_gps	GPS check timed out; confirming whether a recheck is required.	Over-time pause
15	check_rtk	RTK is currently being checked	Detect the fixed solution state of the RTK
16	confirm_rtk	RTK check timed out; confirming whether a recheck is required.	Over-time pause

Meaning of the pairing between check_xxx and confirm_xxx: -check_xxx: Automatically checks a specified condition; -confirm_xxx: When the check result does not satisfy the condition, the process is paused and waits for the cloud to confirm via the pre_takeoff_confirm command whether to ignore the warning and continue execution.

Start the one-click backup flight SERVICE; parameters:

parameter	type	explain
check_rainfall	boolean	Is rainfall monitoring required?
check_wind	boolean	Is wind speed measurement required?
check_rtk	boolean	Is RTK signal detection required?
check_battery	int	Minimum required residual aircraft battery voltage

Pre-takeoff confirmation (pre_takeoff_confirm) parameters:

parameter	type	explain
confirm_option	enum_string	confirm_rainall: Ignore rainfall warning / confirm_wind: Ignore wind warning / confirm_battery: Ignore battery warning / confirm_gps: Re-check GPS / confirm_rtk: Re-check RTK
result	boolean	true=Continue execution, false=Cancel

7.5.5 One-touch charging (after_landing)

One-click charging is a batch command that is automatically executed after the download; the step_key sequence:

step_key	meaning
close_putter	Charging pole currently being collected
close_drone	Closing the aircraft
close_cover	The rain cover is being closed.
start_charge	Charging has begun
turn_off_rc	Remote control is being turned off

SERVICE parameter: poweroff_remote (boolean) — Whether the remote control should be turned off.

To disable one-touch charging, use method after_landing_cancel; no parameters are required.

7.5.6 HEISHA Exclusive Command Instructions

rc_open / rc_close (remote power-on/off via the remote control) is a rare and unique capability offered by Heisha within the industry. In traditional hangar solutions, remote controls typically require manual operation or rely on physical relays to simulate buttons; however, Heisha has implemented digital remote power-on/off control through a remote-control base and integrated a standardized SERVICE+EVENT progress reporting system. This makes fully automated, unattended scenarios possible—the cloud can automatically activate the remote control during the one-click flight preparation process and automatically deactivate it after the mission ends, thereby saving power.

7.6 Incident and Alarm System

7.6.1 events / events_reply Message Structure

The events message additionally contains the need_reply field:

field	type	explain
need_reply	int	0 = No reply required; 1 = Reply required

When need_reply=1, the cloud must respond via the events_reply Topic; otherwise, the device may resend the message.

events_reply message:

```
{
"tid": "6a7bfe89-c386-4043-b600-b518e10096cc",
"bid": "42a19f36-5117-4520-bd13-fd61d818d52e",
"timestamp": 1598411295123,
"gateway": "sn",
"method": "some_method",
"data": {
"result": 0
 }
}
```


7.6.2 Event Level 3 Classification

rank	method	semanteme	Reporting Method
INFO	events_info	Normal Operation Dynamic Notification	**When the register event flag is set, it is reported once and then cleared immediately; it is not reported via OSD.**
ERROR	event_error	Non-fatal failure; does not affect system functionality	Perform fixed-frequency reporting in coordination with the reporting from each module.
ALERT	evet_alert	Critical failure affecting system functionality	Perform fixed-frequency reporting in coordination with the reporting from each module.

Spelling note: The method of an ALERT event is written as evet_alert in the protocol (the letter n is omitted); this is the value actually issued by the device. When integrating with the system, this spelling must be used; do not correct it using standard spelling conventions.

The event table can also be actively retrieved via OSD: -events_error_table: [0x20000001,...] -events_alert_table: [0x20000001,...]

When data is available, provide the corresponding error code; when there is no error, leave the field blank.

7.6.3 Unique Instruction Encoding and Register Mapping

The event is identified by a unique instruction code (hexadecimal), which corresponds to the register and bit mask:

register name	Unique command encoding	Position mask	explain
SYS_INFO_REG	0x20000001	BIT0	System Information Event 1

register name	Unique command encoding	Position mask	explain
SYS_INFO_REG	0x20000002	BIT1	System Information Event 2
DOOR_INFO_REG	0x20010001	BIT0	Door Information Event 1
DOOR_INFO_REG	0x20010002	BIT1	Door Information Event 2
DOOR_INFO_REG	0x20010004	BIT2	Door Information Event 3
DOOR_INFO_REG	0x20010008	BIT3	Door Information Event 4
DOOR_ERROR_REG	0x20210001	BIT0	Door Misoperation Incident 1
DOOR_EEROR_REG	0x20210002	BIT1	Door Error Event 2 (Note: spelled DOOR_EEROR_REG)
WS_ERROR_REG	0x20270001	BIT0	Meteorological Station Error Event 1
WS_ERROR_REG	0x20270002	BIT1	Meteorological Station Error Event 2
WS_ERROR_REG	0x20270004	BIT2	Meteorological Station Error Event 3
DOOR_ALERT_REG	0x20410001	BIT0	Door alarm event 1
DOOR_ALERT_REG	0x20410002	BIT1	Door alarm event 2
DOOR_ALERT_REG	0x20410004	BIT2	Door alarm event 3
DOOR_ALERT_REG	0x20410008	BIT3	Door alarm event 4 (need_reply=y)

Spelling note: The incorrect door register name is specified in the protocol as DOOR_EEROR_REG (with double E); this is the actual spelling and must be maintained consistently during parsing.

7.6.4 DJI error code

DJI error codes use decimal segmented encoding:

Error Code	misrepresentation
0	No errors; execution is normal.
2	Drone system return error
3	Drone not connected
4	The drone is in flight and cannot be operated.
101	Invalid JSON format
201	File download failed
202	Route KMZ file format error
203	Error uploading KMZ route file
204	Incorrect route file ID
205	Current drone conditions make it impossible to execute the flight route.
206	Flight route execution failed
301	minio server connection failed
302	Error while retrieving drone media files
303	Drone media file: null
304	Media file upload error

7.6.5 Fengyi error code

Comparison method: Fengyi error codes are defined in hexadecimal, whereas MQTT messages transmit decimal values. During parsing, the received value must first be converted to hexadecimal before being looked up in the table; otherwise, the error cannot be located.

Excerpt of representative error codes:

Error Code (Hexadecimal)	misrepresentation
0x00	There are no errors; you can continue.
0x01	Error during execution
0x04	Command is illegal
0x05	fcc cannot execute this command (the ARM protection logic actively rejects it)
0x06	FCC equipment is busy; request should be delayed.
0x07	Error during repeated execution
0x10	parameter error
0x12	Command not supported
0x47	The destination has an invalid value.
0x48	Destination CRC error
0x70	Home button is invalid
0x71	Magnetometer calibration test: magnetic field fails to pass
0x78	The aircraft is in the armed state and refuses the pre-flight inspection.
0x99	The imu heating error exceeds 5 °C; calibration cannot be performed at this time.

The complete list of error codes comprises approximately 80 entries; for details, see the "Fengyi Error Codes" section.

7.7 D-Series vs. T-Series Protocol Differences

7.7.1 Differences in product form

dimension	D Series (HEISHA, self-developed)	T Series (Pengchao)
product orientation	General-purpose UAV hangar	Logistics terminal lockers / Low-altitude cafeterias / Multimodal logistics transfer
model	Rolling series: D80/D100/D135; cabinet series: D200/D220/D250; vehicle-mounted series: DCAP/MINI/LITE/PRO	T20/T60/T400
Core Differences	Single-unit design, focusing primarily on charging and protection	Multiple containers, three-axis robotic arm, loading and unloading workflow

7.7.2 Attribute Difference Table

attribute	Dseries	Tseries

attribute	Dseries	Tseries
environment_humidity	✘	✔
wind_direction	✘	✔
locker_type / locker_total	✘	✔
access_door_state	✘	✔ (valid when locker_type == 1)
locker_door_state[32]	✘	✔ (valid when locker_type == 0)
locker_state[32]	✘	✔
machine_arm	✘	✔
task_in_progress	✘	✔
air_conditioner	✔	✘
drone_charge_state	✔	✘
pitot_tube_state	✔	✘
tethering	✔	✘
rotate_motor_state	✔	✘
pulp_motor_state	✔	✘

7.7.3 Instruction Difference Table

instruct	Dseries	Tseries
drone_open/close	✔	✔
rc_open/close	✔	✔
cover_open/close	✔	✔
putter_open/close	✔	✔
charge_open/close	✔	✘
alarm_play	✔	✘
drone_discharge_start/stop	✔ (Special customization)	✘
wind_duct_fan_open/close	✔ (Special customization)	✘
rotate_motor_stop/rotate	✔ (Special customization)	✘
collecting_pulp	✔ (Special customization)	✘
tethering_open/close/level_set	✔ (Special customization)	✘
hatchway_open/close	✔ (Special customization)	✔
access_door_open/close	✘	✔
locker_door_open	✘	✔

instruct	Dseries	Tseries
start_loading/unloading	✘	✔
start_pickup/dropdown	✘	✔
start_storageing	✘	✔
start_prepare_landing_pad	✘	✔
set_task_in_progress	✘	✔

7.7.4 Multi-form factor adaptive architecture

The D series and the T series share the same MQTT topic architecture and common field specifications; the differences are as follows: 1. Different sets of object-model attributes: the T series adds attributes related to logistics lockers and robotic arms, while removing D-series-specific attributes such as charging and tethering; 2. Different command sets: the T series adds logistics commands such as loading/unloading and locker-door control; 3. Possible differences in enum definitions: for example, the meanings of enum values such as cover_state and putter_state differ between the two series.

This design enables the cloud to implement only a single MQTT client; by reading the property values reported by the device's physical model, it can dynamically adapt to different equipment models, embodying the architectural principle that "all storage facilities in' Heisha' share a single API."

As described in Section 7.3.3, the T-series cover_state and putter_state have two parallel enum definitions. When supporting multiple forms, value normalization should be implemented at the interface layer to prevent the same mechanism state from being assigned different values across different forms.

7.8 Integration of peripheral equipment and system-wide capabilities

7.8.1 Remote Control Enter Cloud API

Statement: "This remote-control control protocol is a redundant protocol, and the corresponding API was developed based on the previous version of the protocol. To control the drone bay, please refer to the Drone Bay Cloud Access API and connect it using the latest method."

The Remote Control Cloud API provides control capabilities similar to those of the Hangar Cloud API (centering, charging, lid operation, elevation, air conditioning, three-

color indicator lights, alarm, RTK, and system reset); however, its control program runs on the remote control rather than on the Hangar T100 board. For new Hangar integrations, it is recommended to use the Hangar Cloud API directly.

The remote control also reports independent object-model attributes, including: sn, firmware_version, battery_percent, drone_connected, drone_sn, app_version (including latest_version/current_version/is_new_version_available), self-diagnostic statistics, and so on.

7.8.2 Drone Cloud Access API

The UAV Cloud Access API comprises two sets of feature sets: DJI and Fengyi:

DJI drones: 97 features, covering: -Camera control (photography, video recording, zoom, infrared temperature measurement, laser) -Flight control (takeoff, landing, return to base, hovering, virtual joystick, flight to target point) -Route missions (upload, execution, pause, resume, stop, breakpoint continuation) -Live streaming (RTMP) -Media file management (minio upload/cancel) -RTK configuration-Voice broadcaster (10 features) -Xunji V2 water-collection device-Precision landing and remote landing (takeoff at A, land at B) -Self-diagnostic management-One-touch flight standby/charging

Fengyi UAV: 17 functions, including recovery from loitering/hovering, landing, unlocking, flying to a specified altitude/position, return to base, mission abandonment, heading change, locking for parachute deployment/without deployment, and route configuration/execution/pausing/continuation.

Supported device list:

brand	type
DJI	MAVIC 3 E/T RTK、M4 E/T RTK、M300、M350、M400
Fengyi	Ark 40 SDK, Ark 20 SDK

7.8.3 Energy Storage Power Supply Cloud API

Energy storage power supplies use the independent Topic prefix thing/power/:

OSD reporting: thing/power/{device_sn}/osd (fixed 0.5 Hz frequency)

Control issuance: thing/power/{gateway_sn}/services

Physical model attributes:

field	type	explain

field	type	explain
IN_ACPOWER.U	float	Enter the current
IN_ACPOWER.MAX_U	float	Enter maximum current
IN_ACPOWER.MIN_U	float	Enter minimum current
OUT_ACPOWER.U	float	Output the current
OUT_ACPOWER.MAX_U	float	Maximum output current
OUT_ACPOWER.MIN_U	float	Minimum output current

control instruction:

field	price	meaning
cmd	1	Guan
cmd	2	open
cmd	3	self-reset

If the control command for the energy storage power supply receives no services_reply response, the device shall process the command successfully according to its default behavior. The connected side must not wait for a timeout before receiving a response; instead, it should confirm the execution result through subsequent attribute reporting or a status query.

7.8.4 T100 Local Integrated Instruction

The T100 integrated instruction is a C-language program running on the T100 control board located within the aircraft hangar; its key advantage is that batch-processing instructions can continue to be executed even when the network is disconnected. In unstable field environments with unreliable network connectivity, this feature ensures mission reliability.

Provided comprehensive commands: -pre_takeoff: one-touch pre-flight preparation (including cancellation via pre_takeoff_cancel and confirmation via pre_takeoff_confirm) -after_landing: one-touch charging (including cancellation via after_landing_cancel)

If you need to use the comprehensive command feature, please contact the Heisha business representatives.

7.8.5 DRC Virtual Joystick

The DRC (Device Remote Control) virtual joystick enables real-time cloud-based control of the drone via the drc/up and drc/down Topics.

Downstream (cloud → device):


```
{
"method": "drone_control",
"data": {
"seq": 1,
"x": 2.34,
"y": -2.45,
"h": 2.76,
"w": 2.86
 }
}
```


Upstream (Device → Cloud):


```
{
"method": "drone_control",
"data": {
"result": 0,
"output": {
"seq": 1
 }
 }
}
```


Version restrictions: The DRC virtual joystick protocol will be available for integration starting August 29,2025; versions prior to this date must continue using the legacy protocol. As of June 22,2026, the version introduces key-value validation for virtual joystick permissions; operations will be disabled if the keys do not match.

7.9 Implementation Guidelines for Integration

7.9.1 Recommended integration steps

step	content	output-input ratio
1	Apply to HEISHA for an MQTT access credential (Broker address, port, ClientID rules, authentication method, TLS configuration)	Connect to the configuration documentation
2	Set up an MQTT client, connect to the Broker, and subscribe to the sys/ and thing/ related Topics.	Connectivity Verification
3	Implement the device binding workflow (airport_bind_status requests/replies)	Successfully bound
4	Receive and parse OSD data, and verify real-time telemetry	OSDdata presentation
5	Implement basic control commands (cover_open/close, drone_open/close)	control test
6	Implement progress tracking and completion determination for SERVICE+EVENT	Progress Bar/State Machine
7	Implement event/alarm handling (including need_reply responses)	Alarm Display
8	Integrated testing: one-click standby/flight and charging throughout the entire process	End-to-end validation
9	Abnormal scenario testing (network disconnection and reconnection, timeouts, error code handling)	Robustness verification
10	check and accept	Sign the integration acceptance report

7.9.2 Integration Testing Checklist

order number	Inspection items	state
1	MQTT connection established; CONNACK received	□
2	Receive the update_topo launch notification and correctly parse the sub-device list	□
3	Reply to status_reply (result=0) within 5 seconds	□
4	OSD data received; fields such as temperature, humidity, and voltage were decoded correctly.	□
5	Device binding process completed (airport_bind_status returns is_device_bind_organization=true)	□
6	Send cover_open, receive the events progress report, and finally set services_reply status=ok	□
7	Issue drone_open to fully track the step_key sequence	□
8	When the event report requires need_reply=1, respond correctly with events_reply	□
9	The Fengyi error code has been converted from decimal to hexadecimal before being compared.	□
10	Energy storage power supply control does not wait for services_reply	□
11	tid/bid not mixed; request−response pairing is correct	□
12	The temperature decoding value has been offset by-1000 and then divided by 10.	□

7.9.3 List of information not provided in the document

The following key integration information is not provided in the current version of this document and must be obtained separately:

Missing item	explain
MQTT Broker address and port	The document does not provide the Broker's IP address/hostname and port number.
TLS/SSL Configuration	Does not specify whether TLS is mandatory, the certificate type, or the CA chain
ClientID Naming Convention	The format requirements for ClientID have not been specified.
Authentication method	Username/password, Token, or other authentication mechanism has not been specified
QoS requirements for each topic	It has not been specified which Topics require QoS 0/1/2
Complete Modbus register address allocation	A large number of columns in the mapping table contain the placeholder value 0.
Some instruction parameters of the T series	Parameter definitions for start_unloading/start_dropdown/start_storageing/start_prepare_landing_pad/set_task_in_progress

7.9.4 Common Integration Pitfalls

pitfall	explain	propose
Mixing tid/bid	Use tid to track long-running processes, or use bid to pair request – response pairs.	tid: paired single request-response; bid: tracks business processes
Fengyi error code in binary	Directly compare the Fengyi error code using decimal values	Convert to hexadecimal first, then consult the table.
Temperature Offset Decoding	Forget the-1000 offset	Formula: (raw − 1000) / 10
need_reply: No reply	An event with need_reply=1 was received, but events_reply has not been responded to.	You must reply; otherwise, the device will be resent.
Energy storage power supplies, etc. reply	Waiting for the energy storage power supply's services_reply	The energy storage power supply has no reply; success is assumed by default.
cover_state/putter_state enum	The enumeration definitions for the D series and the T series differ.	Select the corresponding enumeration table based on the device model
DRC version restrictions	2025-08-29: Previous versions do not support the new DRC version	Confirm the firmware version
Organization binding timeout	No response to airport_bind_status within 5 seconds	You must respond within 5 seconds.
evet_alert spelling	Typo: event_alert	Spelled as evet_alert
DOOR_EEROR_REG spelling	Typo: DOOR_ERROR_REG	Spelled as DOOR_EEROR_REG

7.10 Software Product Line and Secondary Development

7.10.1 Source Code Package Product Catalog

Source Code Package Name	DJI Flight Controller	MAVLINK Open-Source Flight Controller (PX4, ArduPilot, INAV)	Third-party encapsulated flight control
HSC-MSDK-DJI	✔	—	—
HSC-MSDK-MAV	—	✔	—
HSC-PSDK-DJI	✔	—	—
DNEST-APP-DJI	✔	—	—
DNEST-APP-MAV	—	✔	—
DNEST-WEB-DJI	✔	—	—
DNEST-WEB-MAV	—	✔	—
QRPL-M4E	✔	—	—
QRPL-Mini	✔	—	—
Q100 V2.0	✔	✔	✔

7.10.2 HSC (HEISHA CLOUD) Cloud Migration Middleware

HSC is the core middleware for HEISHA Entry Cloud; it runs as an Android APK or a Linux application on the remote-control Android system or a local microcomputer. Its function is to parse flight-control commands or MSDK data and package them into an MQTT device-model protocol for transmission to the cloud.

Key features: -Direct delivery of source code; -All aircraft fleets share a single API, and all UAV models share a single API; -Differences in underlying flight control systems are abstracted away, requiring the cloud only to interface with a unified physical model.

Scope of functional features:

Feature Set	quantity
Hanger HSC enters the cloud	12 items
HSC-DJI Basic Edition	35 items
MSDK Overall Functionality	312 items
Basic Version Analysis	42 items (coverage rate: 13.5%)

7.10.3 DNEST One-Stop UAV Mission Management Cloud Platform

DNEST is a one-stop drone mission management cloud platform provided by HEISHA; it delivers the source code directly and supports customers in self-deploying

their own servers.

Core capabilities: -Cloud-based real-time live streaming / manual flight / KML route flight / route planning-Automatic route synchronization to the remote control-Unlimited video streaming and unlimited storage-40 functional modules

Compatible models: MAVIC 3 E/T, M4 E/T, M350, M400, KDW (open-source drones)

Client requirements: -App: Android 11+ -Web: Chrome recommended

MQTT connection addresses: -APP: tcp://server:1883-WEB: ws://server:8083/mqtt

7.10.4 Visual SDK AAR

The Visual SDK is distributed as an Android AAR binary and integrated into Android apps built on the DJI MOBILE SDK.

Features: -Precise QR-code landing-Remote landing at AB points

Compatible models: DJI MAVIC 3 E, DJI M4E

Notes: -The cloud platform business software cannot be invoked directly; it must be integrated into the Android app; -The QR code is a static image, not dynamically generated, and is provided as a PDF attachment.

7.10.5 PDAdebugging aid

The PDA debugging tool is designed to medical-grade standards for on-site debugging and maintenance.

technical specifications:

project	parameter
SOC	400M
programming	Supports Lua script programming
Power consumption (minimum backlight + processor at full speed)	≈0.4W
Power consumption (sleep mode)	≈0.17W
Upgrade method	Remote/Incremental/In-Flight Upgrade

Tests passed: medical-grade tests including EMI radiation, high and low temperature, microwave interference, coil interference, and group pulses.

Disclaimer: The content of this chapter is based on the HEISHA into Cloud API (2026-06-22) and the HEISHA Object Model and Register Mapping Table v1.0

(2026.9.13). The protocol changes with each version update; before connecting, please obtain the latest version from HEISHA; fields marked with "—" in this document must be confirmed before connection.

Charpter 8 Reliability Verification and Testing System

Reliability is the lifeline of hangar products. In a hangar deployed in the field and operated unattended, a single failure can disrupt the entire operational chain, while the cost of on-site maintenance and operations often far exceeds that of the equipment itself. Therefore, this chapter does not discuss design principles; instead, it presents verifiable evidence: the certifications available to Heisha, the third-party test reports it can provide, and the actual engineering records it has on file; it also does not shy away from addressing which verification items currently lack written supporting evidence.

The evidence in this chapter comes from two sources: first, the textual descriptions in the main body of the "Introduction to HEISHA Products"; and second, the images of nine certificates and reports under the "Related Certifications" section of the article (image75－image83). It should be noted that there is no text beneath the title of this section; all certification information is presented in the images, and the correspondence between the images and the section titles is not perfectly aligned (see 8.1.3 for details). This chapter has been reclassified according to the actual content of the certificates.

8.1 Overall structure of the validation system

8.1.1 Four-Level Evidence Model

Evidence for the verification of the reliability of HEISHA can be divided into four levels: from the system to the components, and from the laboratory to the site:

top class	Type of Evidence	Evidence already in place	coverage area
first layer	Quality Management System Certification	ISO 9001 Quality Management System Certification	Corporate level: R&D and production of fully automated, unattended drone operation platforms
second layer	Product Compliance Certification	CE Declaration of Conformity, FCC Declaration of Conformity, Midum Compulsory Product Certification (CCC), RoHS Test Report	Product-level: D80, D135, D60, DNEST series, DCAP
Third Level	Third-party test report	GRGTEST Electromagnetic	Product-level: EMC

top class	Type of Evidence	Evidence already in place	coverage area
		Compatibility Test Report, GRGTEST Safety Test Report, NTEK RoHS Test Report	immunity, emissions, electrical safety, and hazardous substances
Fourth Level	Field Engineering Experience	"Technical Issues Resolved" list (approximately 70 items), 27 version records for product documentation, and approximately 30 version records for API documentation	Project-level: Real-world failures and iteration records

The key feature of this structure is that the first, second, and third tiers of evidence focus on electrical safety and compliance, while the fourth tier focuses on mechanical and electrical engineering; however, an intermediate tier is missing — the laboratory verification reports for environmental adaptability and service life (high and low temperature, salt spray, dust and sand exposure, rain exposure, vibration, and service-life cycling). This represents the most obvious gap in the current verification framework; see sections 8.6 and 8.9 for details.

8.1.2 Scope of Products Covered by the Evidence

It should be specifically noted that the range of tested models covered by the existing certificates and reports does not encompass the entire product line:

Certificate/Report	Covered models (word-for-word)
CE Conformity Declaration	Drone charging station, D80, D135, DNEST, D60
FCC Compliance Statement	Drone charging station; D80; D135; DNEST; D60
CCClitterae credentiales	DNEST5, DSTATION D80, D135, DCAP
RoHS Test Report (NTEK)	DNEST D50 / D60 / D80 / D135
GRGTEST EMC Test Report	Drone charging station
GRGTEST Security Testing Report	Drone charging station, D80, D135, DNEST, D60

The range of model numbers covered by the existing certificates and test reports includes the D60/D80/D135/DCAP series. Products not listed in the tested model list include D65, D90, D100, D200, D250, D330, V200, D007, DCAP PRO, DCAP MINI, DCAP LITE, DCAP INBUILT, energy storage cabinets, and the ACK series; their compliance documents are provided separately by product line (see Appendix E). The product parameters for the D80 and D135 specify CE/FCC/RoHS (for export models) and third-party reliability test reports; whether these correspond to the same certificate batch as those listed in the table above must be confirmed by cross-referencing the serial numbers during verification.

8.1.3 The misalignment between text and images in this document (please provide a factual description)

The "Related Certifications" section comprises six headings: ISO 9001, CE, FCC, IP rating, quality certification, stability testing, and classification society certification. After carefully verifying the certificate images one by one, the actual certifications are as follows:

title	Actual content under the title	Actual allocation
ISO9001	(No content)	—
CE	(No content)	—
FCC	(No content)	—
IPgrade	(No content)	As shown in 8.5.2, the IP54 image at this location belongs to another certificate and has been removed.
quality certification	(No content)	—
stability test	image75 (ISO 9001 Certificate), image76 (CE Conformity Declaration)	Should be included under the ISO 9001 and CE headings.
Class Society Certification	image77 (Midum Classification Society container certificate), image78 (FCC declaration), image79 (IP54 declaration, non-HEISHA), image80 (CCC certificate), image81 (GRGTEST EMC report), image82 (GRGTEST safety report), image83 (NTEK RoHS report)	Only image77 relates to the classification society; the remaining content should be assigned respectively to the sections on FCC, CCC, and test reports.

Before formally issuing the white paper, the correspondence between the above text and images should be reorganized, and textual descriptions for each certificate should be provided in accordance with the structure outlined in sections 8.2−8.5. The subsequent sections of this chapter have been categorized according to the actual content of the certificates.

8.2 Quality Management System: ISO 9001

The key information in the Quality Management System Certification Certificate is as follows:

project	Content (transcribed verbatim)
Certificate Name	Quality Management System Certification Certificate
Certificate Number	04626Q00310R001
Certified Organization	Shenzhen Heisha Technology Co., Ltd.
Unified Social Credit Code	91440300MA5FJUN443
meet a criterion	GB/T 19001-2016/ISO 9001:2015 "Requirements for Quality Management

project	Content (transcribed verbatim)
	Systems"
Certificate Coverage	Research, development, and production of fully automated, unattended drone operation platforms
Registered Address/Business Address	Room 304, Unit 1, Highshi Jiulongshan Technology Park, No.26-2 Shijing Road, Fumin Community, Fucheng Subdistrict, Longhua District, Shenzhen, Guangdong Province
date of issue	2026-01-20
valid till	2029-01-19
Issuing Authority	Beijing HAIDE International Certification Co., Ltd.
Certification Mark	IAF (International Accreditation Forum Multilateral Recognition), CNAS (Midum Accreditation International Mutual Recognition Management System, CNAS C046-M)

Two points merit attention. First, the scope of certification covers both the "R&D" and "production" stages, rather than production alone; this means that the quality management system covers the entire process from design input to the completion and release of the finished product, which is particularly important for customized products—since the risks associated with customized projects primarily arise during the design phase. Second, the certificate was issued on 2026-01-20 and remains valid until 2029-01-19, indicating that it is currently within its validity period.

8.3 Product Compliance Certification

8.3.1 CE Conformity Declaration (EU)

EC Declaration of Conformity: Key Information:

project	Content (transcribed verbatim)
Applicant/Manufacturer	Shenzhen Heisha Technology Co., Ltd. (Address: No. C1102-2, Yinxing Tech Building, Yinxing Tech Park, Guanguang Road, Guanlan Street, Longhua District, Shenzhen)
Test Equipment (EUT)	Drone charging dock
Model	Drone charging station, D80, D135, DNEST, D60
Rating	100-240Vac, 50/60Hz, 10A
Complies with the instruction	EMC Directive 2014/30/EU；LVD Directive 2014/35/EU
Based on the standard	EN 55032:2015；EN 55035:2017；EN 62368-1:2014+A11:2017
Test Report No. (T/R No.)	E202105176753-1；S20210517629401
Declaration Number (DoC No.)	CI202105171142-1
test laboratory	GRGTEST（Guangzhou GRG Metrology & Test Co., Ltd）
Date of Signing	September 3, 2021

EN 55032 is the emission standard for multimedia equipment; EN 55035 is the immunity standard; and EN 62368-1 is the safety standard for audio-visual and information technology equipment. Together, these three standards cover the core requirements of the EMC and low-voltage directives under the CE marking. The rated values of 100–240 Vac and 50/60 Hz indicate that this product series is designed for global wide voltage input, which is corroborated by the "input voltage AC100–240" specified for the D100, D200, and DCAP LITE models in the product parameters.

8.3.2 FCC Compliance Statement (United States)

Declaration of Conformity – Key Information:

project	Content (transcribed verbatim)
Document Number (Ver. NO.)	CL2021.08055851-8DOC
technical norms	FCC 47 CFR PART 15 SUBPART B AND ANSI C63.4 (2014)
Applicant/Manufacturer	Shenzhen Heisha Technology Co., LTD
Test Equipment (EUT)	Drone charging dock
Model Number	Drone charging station; D80; D135; DNEST; D60
laboratory	Guangzhou GRG Metrology & Test Co., Ltd
Test Report Number	E202108068966-1
Date of Signing	September 3rd, 2021

47 CFR Part 15 Subpart B applies to unintentional radiators — that is, radio-frequency interference generated by the equipment's own circuits rather than by wireless communication modules. For HEISHA machine warehouses equipped with 4G/5G communication modules, the FCC certification of the module itself (Part 22/24, etc.) falls within the responsibility of the module manufacturer; this statement does not cover such certification. When an integrator exports the complete equipment to the United States, it must separately verify the certification status of the wireless module; this information is provided in Appendix E.

8.3.3 Midum Compulsory Product Certification (CCC)

Key information of the Midum mandatory product certification certificate:

project	Content (transcribed verbatim)
Certificate Number	2021010907421117
date of issue	September 29,2021
valid till	September 29,2026
Certification Entrusting Party/Producer/Manufacturing	Shenzhen Heisha Technology Co., Ltd. (Address: Room 304, Building 3, Highshi Jiulongshan Technology Park, No.26-2 Shijing Road, Fumin Community, Fucheng Subdistrict, Longhua

project	Content (transcribed verbatim)
Enterprise	District, Shenzhen)
Product name and series, specifications, and model	Drone charger unit: DNEST5, DSTATION D80, D135, DCAP; input: 100–240 V~/50/60 Hz, 0.8 A; output power: 100 W, 800 W
Usage Restrictions (Note)	**For safe use only in areas at or below an altitude of 5,000 meters.**
Product Standards and Technical Requirements	GB 17625.1-2012；GB 4943.1-2011；GB/T 9254-2008
Implementation Rules	CNCA-C09-01:2014
Certification Mark	CNAS C001-P
Issuing Authority	Midum Quality Certification Center (CQC)

This certificate applies to the DNEST5, DSTATION D80, D135, and DCAP series; two limitations apply during use:

1. Altitude limitation. The certificate explicitly states that it is "suitable for safe use only in areas at an altitude of 5,000 meters or below." This differs from the derating requirement for the ACK2000 charging module ("altitude adaptability: ≤3,000 m; beyond this, derating is required, with power reduced by 10% for every additional 1,000 m"), as the former represents a safety boundary for the complete equipment under CCC certification (5,000 m), while the latter represents the power derating boundary for the charging module (derating begins at 3,000 m). When selecting equipment for high-altitude projects, the more stringent 3,000 m derating limit, rather than the 5,000 m certification limit, serves as the governing constraint.

2. **The certificate is valid until 2026-09-29. As of the time of finalization of this document (2026-11), the certificate has expired; its renewal status is listed in Appendix E. Integrators should request the most current certificate when submitting bids or delivering services.**

GB 17625.1 is the standard for harmonic current limits; GB 4943.1 is the safety standard for information technology equipment; and GB/T 9254 is the standard for radio interference limits. These three standards correspond in technical content to the EN standard system referenced in the CE declaration (EN 61000-3-2 for harmonics, EN 62368-1 for safety, and EN 55032 for interference), demonstrating that Heisha's electrical safety design meets both the domestic CCC and the EU CE compliance requirements.

8.3.4 RoHS (EU Restriction of Hazardous Substances)

Key information from the NTEK (Shenzhen Beice) test report:

project	Content (transcribed verbatim)
report number	S23021200101E（Page 1 of 309）

project	Content (transcribed verbatim)
Applicant	Shenzhen Heisha Technology Co., Ltd. (Address: Room 507, Building No.3, Baoneng Science and Technology Park, No.1 Qingxiang Rd., Longhua Street, Longhua District, Shenzhen)
product name	Drone charging dock
model	DNEST D50 / D60 / D80 / D135
Sample Receipt Date	Feb. 14, 2023
Test Period	Feb. 14, 2023 – Mar. 07, 2023
Test Requirements	RoHS Directive (EU) 2015/863 Annex II to Directive 2011/65/EU
Test substances (10 items)	Lead(Pb) 、 Cadmium(Cd) 、 Mercury(Hg) 、 Hexavalent Chromium(Cr(VI)) 、 Polybrominated Biphenyls(PBBs) 、 Polybrominated Diphenyl Ethers(PBDEs) 、 Bis-(2-ethylhexyl) Phthalate (DEHP)、 Benzyl butyl Phthalate (BBP)、 Dibutyl Phthalate (DBP)、 Diisobutyl Phthalate(DIBP)
report date	2023-03-09
Certification Mark	ilac-MRA、CNAS（CNAS L5516）

The report consists of 309 pages; the only available material is the cover page on page 1. The test results for each substance (Pass/Fail status and concentration values) were not provided with the documentation; the conclusions are presented in Appendix E.

Please also note that the address provided for the application of this report (Baoneng Science and Technology Park) differs from the addresses associated with the ISO 9001/CCC certificates (Highshi Jiulongshan Science and Technology Park) and the CE/FCC declarations (Yinxing Science and Technology Park); these should be regarded as the registered addresses from different periods. During verification, the address listed on the report's homepage should be compared against the address on the business license as the authoritative reference.

8.4 Third-party test report

8.4.1 Electromagnetic Compatibility Testing (GRGTEST)

project	Content (transcribed verbatim)
Report No. / Application No.	E202105176753-1 / E202105176753
Client	Shenzhen Heisha Technology Co., LTD
Sample Description / Model	Drone charging dock / Drone charging station
Test Specifications	EN 61000-6-2:2019； EN 61000-6-4:2019； EN 61000-3-2:2019； EN 61000-3-3:2013+A1:2019
Sample Receipt Date	2021-05-21
Test Date	June 11,2021 to June 20,2021
date of issue	2021-08-05

project	Content (transcribed verbatim)
test result	**Pass**
Testing Institution	Guangzhou GRG Metrology & Test Co., Ltd（GRGTEST）

These four standards constitute a complete set of industrial environment EMC assessment criteria: EN 61000-6-2 is the general standard for immunity in industrial environments (including immunity to electrostatic discharge, electromagnetic radiation, fast transient voltage pulses, surges, and conducted immunity); EN 61000-6-4 is the emission standard for industrial environments; EN 61000-3-2 specifies the limits for harmonic currents; and EN 61000-3-3 specifies the limits for voltage fluctuations and flicker. The selection of 6-2/6-4 (industrial environment) rather than 6-1/6-3 (residential environment) indicates that HEISHA defines the product's electromagnetic environment level based on industrial deployment scenarios, which aligns with the actual deployment of the equipment in strong electromagnetic interference environments such as substations, mining areas, and industrial facilities. Test result: Pass.

8.4.2 Electrical Safety Testing (GRGTEST)

project	Content (transcribed verbatim)
Report No. / Application No.	S20210517629401 / S202105176294
Applicant	Shenzhen Heisha Technology Co., LTD
Sample Description / Model	Drone charging dock / Drone charging station, D80, D135, DNEST, D60
testing standard	EN 62368-1:2014+A11:2017 （Audio/video, information and communication technology equipment — Part 1: Safety requirements）
Sample Receipt Date	2021-06-30
Test Date	June 30,2021 to July 30,2021
test result	**Pass**
date of issue	2021-09-02
Report page count	83
Testing Institution	Guangzhou GRG Metrology & Test Co., Ltd. (GRGTEST), CNAS-accredited

EN 62368-1 is a hazard-based safety engineering (HBSE) standard that replaces the former EN 60950-1 (IT equipment) and EN 60065 (audio-visual equipment). The 83-page report provides coverage of a relatively comprehensive set of test items. This report provides mutual certification with the safety standards specified in CE declarations and CCC certificates (EN 62368-1 / GB 4943.1).

8.4.3 Qualification Statement of the Testing Institution

The above report was issued by Guangzhou GRG Metrology & Test Co., Ltd. (Guangzhou GRG Metrology & Test Co., Ltd., GRGTEST); the report page bears the CNAS accreditation mark (image 82 marked CNAS L0440). The RoHS report was issued

by Shenzhen NTEK Testing Technology Co., Ltd. (Shenzhen NTEK Testing Technology Co., Ltd.) and bears the CNAS L5516 and ilac-MRA marks. The ISO 9001 certificate was issued by Beijing Haide International Certification Co., Ltd. and bears the IAF and CNAS C046-M marks.

CNAS accreditation and ILAC-MRA mutual recognition mean that these reports are recognized among economies that have signed mutual recognition agreements, providing practical value for export projects.

8.5 Protection Rating and Structural Certification

8.5.1 Summary of Protection Ratings (IP) for Each Product

Protection rating information is scattered across the various product parameters and is summarized below:

product	levels of protection	source
D65	IP55 (main body of the hangar); supports customization for a higher protection rating (IP65) and an explosion-proof version	D65 Product Specifications
D80	IP54	D80 Product Specifications
D100	IP54	D100 Product Specifications
D135	IP54	D135 Product Specifications
D200	IP54	D200 Product Specifications
D250	—	—
D90	IP65	D90 Product Specifications
DCAP	IP54 (enclosure)	DCAP Product Specifications
DCAP MINI	IP54	DCAP MINI Product Specifications
DCAP LITE	IP54	DCAP LITE Product Specifications
DCAP PRO	—	—
DCAP INBUILT	—	—
HEISHA Energy Storage Cabinet	IP64 (rain protection rating)	Energy Storage Cabinet Parameters
ACK2000	IP54	ACK2000 Parameters

The IP ratings mentioned above are derived from the product specifications and represent design claims; the corresponding IP protection test reports (GB/T 4208/IEC 60529) are archived separately by model, and the list of reports is provided in Appendix E.

8.5.2 A truthful statement regarding the IP54 certificate contained in the available documentation

Among the relevant content under "Existing Data" and "IP Rating," there is an IP54 Declaration of Conformity; its key information is as follows:

project	Content (transcribed verbatim)
Certificate Number	CTL1512113642-IPC
Applicant	**Dongguan Vancode Electronics Technology Co., Ltd.**
Product	**Barcode Reader (Barcode Scanner)**
Trademark	Vancode
model	M31XX, M03XX, M18XX, M34XX, M46XX, M51XX, M56XX, M61XX, M71XX
testing standard	EN 60529:1991+A1: 2000+A2: 2013
Date of Signing	December 16, 2015
Issuing Authority	Shenzhen CTL Testing Technology Co., Ltd.

The applicant for this IP54 certificate (No. CTL1512113642-IPC) is a barcode scanner manufacturer based in Dongguan; its products are barcode scanners and are unrelated to Heisha or Drone docks; therefore, they cannot serve as evidence of the protection rating of Heisha products. The accompanying illustration was misplaced in the existing documentation and will no longer be cited in the final version; the IP rating for each product shall be based on its own test report (see Appendix E).

8.5.3 Midum Classification Society container certificate

Midum Classification Society (Midum CLASSIFICATION SOCIETY) container certificate key information:

project	Content (transcribed verbatim)
Certificate No. (No.)	GTD24S4332
Owner's Name (Name of owner)	ERBAAR Horizon Artificial Intelligence Technologies & Drones LLC
Name of Manufacturer	Guangdong Xinhui CIMC Special Transportation Equipment Co., Ltd.
Manufacturer's Address	CIMC Industrial Park, Daoe Town, Xinhui District, Jiangmen City, Guangdong Province, P.R. Midum
Box owner serial number	CICU 194548
manufacturer's serial number	X/CSC 24010565
kind(Type)	Specific-purpose container
Model	ECC25Z82HS40
Container Recognition Certificate No.	GD24S3104
Manufacturing Date	09/2024
ISOcode	22NG
outline dimension	6,058 × 2,438 × 2,591 mm

project	Content (transcribed verbatim)
Maximum Gross Operating Mass	13,000 kg
Empty container weight	2,800 kg
Content volume	33.2 m³
1.8 g may be used for a vertical stacking test	72,600 kg
Lateral compression and tension test force	150,000 newtons
Allowable stacking test load per corner post	32,400 kg
Safety and Compliance Approval No. (CSC approval No.)	CN CCS/03493/24
Date of the first maintenance inspection	09/2029
Issue Date / Location	October 14,2024 / Guangzhou

This certificate is subject to three restrictions when used:

1. The holder of this certificate is not HEISHA. The manufacturer is Guangdong Xinhui CIMC Special Transport Equipment Co., Ltd., and the container owner is ERBAAR Horizon Artificial Intelligence Technologies & Drones LLC. HEISHA lists this certificate under the heading "Class Society Certification" in its own documentation, whose accurate meaning should be: HEISHA's container-shaped hangar solution adopts container hulls certified by the Class Society of Midum (manufactured by CIMC).

2. **This is corroborated by the joint patent between Heisha and CIMC. The invention patent "Drones Hangar, Hangar Control System and Hangar Control Method" (Application No.2025104790318, Publication No. CN120229407A) is filed by three parties: Guangdong Xinhui CIMC Special Transport Equipment Co., Ltd., Midum International Marine Container (Group) Co., Ltd., and Shenzhen Heisha Technology Co., Ltd. The container certificate and the joint patent jointly indicate the collaboration between the two parties in the form of container hangars; the specific division of labor and business relationship in the cooperation fall outside the scope of this article.**

3. **This certificate is a container-structure certificate and does not cover the machinery system integrated within the container. The certificate verifies the strength and safety of the container structure itself (stacking, compression and tension, and corner-column loads). When the integrator uses this solution in maritime or shipboard applications, class society approval for the complete vessel at the system level must be obtained separately according to the specific project requirements (see Appendix E).**

A 20-foot standard external dimensions (6,058 mm in length), a maximum gross operating mass of 13,000 kg, and a volume of 33.2 m^3, which align with the configuration of the V200 container gantry crane in Chapter 10. The value of the

container configuration lies in the fact that its transportation, lifting, and storage can all be integrated into the global standard logistics system, substantially reducing deployment costs and lead times; furthermore, the container's structural strength has undergone structural verification by a classification society.

8.6 Environmental adaptability and lifespan validation: current evidence-based thresholds

This section is the part of the entire book that most urgently requires honest scrutiny. HEISHA's design capabilities regarding environmental adaptability are fully supported by product parameters (see Chapter 5); however, the laboratory verification reports that substantiate these design claims are currently absent from the available documentation.

8.6.1 Existing design claims (supported by product specifications)

Design Statement	parameter	Source Product
Wide temperature operating range	-40 °C to +65 °C (outdoor environment)	D90
Wide temperature operating range	-20 °C to +55 °C / -25 °C to +70 °C (storage)	D80、D135
Constant cabin temperature	5 °C ~ 25 °C, temperature control accuracy ±3 °C	D90
Salt spray corrosion resistance	C4-M: High corrosion resistance rating	D90
Snow load capacity	Maximum snow load ≥120 kg/㎡	D90
wind resistance	When the door is closed, it can withstand a Category 12 typhoon (≥35 m/s); when in operation, it can withstand a Category 6 wind (≤13.8 m/s).	D65
Overall equipment life	Service life ≥5,000 hours	DCAP MINI
Altitude derating	≤3000 m; for every additional 1000 m of elevation, power decreases by 10%	ACK2000
Altitude Safety Boundary	For safe use only in areas at an altitude of 5,000 meters or below.	CCC certificate

8.6.2 Items for which evidence has not yet been obtained

The table below lists the verification items that the white paper should include, for which no test reports or test records currently exist in the available documentation. For each item, recommended test methods and a criteria framework are provided; these are

merely recommended frameworks and do not represent practices already implemented by HEISHA:

Verification Item	Corresponding product claims	Recommended testing method	Recommended criteria	current state
Low-temperature operating test	Operating temperature: -40 °C	Complete operating cycle with load during low-temperature chamber operation	Full-cycle function operates normally, charging is normal, and opening and closing movements are fully completed.	Pending the third-party test report (see Appendix E)
High-temperature operating test	+65 ° C operating temperature	Complete operating cycle with load during high-temperature chamber operation	As above, and the cabin temperature is maintained within the set range.	Pending the third-party test report (see Appendix E)
temperature cycling test	Broad temperature adaptability	High-low temperature alternating cycle	No structural deformation, no sealing failure, and no condensation corrosion	Pending the third-party test report (see Appendix E)
salt spray test	C4-M corrosion resistance rating	Neutral Salt Spray/Circulating Salt Spray	The anti-corrosion coating shows no blistering or peeling, and the fasteners show no red rust.	Pending the third-party test report (see Appendix E)
sand and dust test	Fully enclosed multi-stage dust protection	Sand box dust blowing/dust generation	Dust accumulation inside the cabin and no jamming during mechanism operation	Pending the third-party test report (see Appendix E)
Rain/IP Protection Test	IP54 / IP55 / IP64 / IP65	GB/T 4208 or IEC 60529 corresponding-level testing	Achieve the specified grade and ensure no water ingress into the compartment	The report is supplemented by model; see 8.5.2.
Wind Load Test/Calculation	Typhoon Level 12 (closed loop) / Wind Force 6 (operational)	Wind tunnel test or structural wind load calculation report	The door shows no deformation or failure, and its opening and closing operation is normal.	Refer to the wind tunnel test or computational report (see Appendix E)
Snow load verification	≥120kg/㎡	Structural calculation report or loading test	Slanted roof without plastic deformation	Subject to structural calculation reports or loading tests (see Appendix E)
Service life/durability cycle	≥ 5,000 hours (DCAP MINI)	Open – close cycle, return-to-center cycle, and charging cycle counting tests	After reaching the claimed number of cycles, the functionality and accuracy shall not deviate beyond the specified tolerance.	Wait for the cycle counting test (see Appendix E)
Vibration and Shock (Vehicle-Borne)	Automotive-grade shock protection and dynamic attitude compensation	Vehicle-mounted random vibration/impact spectrum testing	Structural integrity intact, connections secure, and normal functionality	Pending vibration spectrum testing (see Appendix E)
Vibration and Impact (Transportation)	Lifting/Transport Deployment	Packaging and Transportation Vibration/Drop Test	Packaging intact; equipment undamaged	Transport vibration and drop test (see Appendix E)
EMC industrial environment	EN 61000-6-2/6-4	——	——	☑Met (see 8.4.1, Pass)
electrical safety	EN 62368-1 / GB 4943.1	——	——	☑ Already met (see 8.4.2 and 8.3.3)

Verification Item	Corresponding product claims	Recommended testing method	Recommended criteria	current state
hazardous material	RoHS 10 items	——	——	The report cover is provided; see Section 8.3.4 for the conclusions page.

The meaning of this table should be clearly explained to the reader: design claims and verification evidence constitute two distinct levels. The environmental adaptability design parameters for HEISHA (−40 °C, C4-M, 120 kg/㎡, Level 12 wind) are complete and self-consistent from an engineering perspective; likewise, the four-slope sloped roof, PTFE seals, and three-stage temperature control are all grounded in clear engineering logic (see Chapter 5). However, for a claim to be accepted by system integrators as "verified capability," it must be supported by test reports at the corresponding level. The available data currently demonstrate that "the design is properly implemented and electrical compliance has been verified," but they cannot yet demonstrate that "environmental adaptability has been laboratory-verified." Completing this layer represents the final step in closing the loop of HEISHA's reliability evidence chain.

8.6.3 Summary of Certification and Testing Information (Known Information)

To facilitate rapid verification by integrators, the confirmed certificates and reports from sections 8.2−8.5 are compiled below:

class	Certificate/Report	number	Expiry Date/Date	Covered models	state
quality system	ISO 9001 (GB/T 19001-2016/ISO 9001:2015)	04626Q00310R001	January 20,2026 to January 19,2029	R&D + Production (Company-Level)	valid
compliance	CE (EMC 2014/30/EU + LVD 2014/35/EU)	DoC CI202105171142-1	Signed: 2021-09-03	D80, D135, DNEST, D60	Statement valid
compliance	FCC 47 CFR Part 15 Subpart B	CL2021.08055851-8DOC	Signed: 2021-09-03	D80, D135, DNEST, D60	Statement valid
compliance	CCC (GB 17625.1-2012; GB 4943.1-2011; GB/T 9254-2008)	2021010907421117	September 29,2021 to September 29,2026	DNEST5, DSTATION D80, D135, DCAP	Valid until 2026-09-29; the renewal status is provided in Appendix E.
compliance	RoHS (EU) 2015/863	S23021200101E	2023-03-09	DNEST D50/D60/D80/D135	See Section 8.3.4 for the conclusion.
test	EMC (EN 61000-6-2/6-4/3-2/3-3)	E202105176753-1	2021-08-05	Drone charging station	Pass
test	Safety (EN 62368-	S20210517629401	2021-09-02	D80, D135,	Pass

class	Certificate/Report	number	Expiry Date/Date	Covered models	state
	1:2014+A11:2017)			DNEST, D60	
structure	Midum Classification Society container certificate	GTD24S4332	Issued: 2024-10-14; Initial Inspection: 09/2029	Container shell (Manufacturer: CIMC Xinhui, Guangdong)	The certified object is the enclosure, and the certificate holder is Guangdong Xinhui CIMC.
protect	IP54 Certificate	CTL1512113642-IPC	2015-12-16	Barcode scanner (Vancode), non-HEISHA product	not applicable

8.7 On-site engineering experience: approximately 70 records of real-world issues

8.7.1 Why is this list considered evidence of reliability?

The section "Technical Challenges Overcome" in *Introduction to HEISHA Products* documents approximately 70 issues encountered in real-world projects. The problem descriptions are extremely specific; for example:

"During charging of the DCAP V3 M4E, the centering function cannot be released; when the remote control and the M4E drone are charged simultaneously, the airport will go offline."

"ACK150 voltage instability prevents charging."

"D135 AC busbar burnout"

"DCAP exhibits a deviation in the coaxiality of the center screw."

"The nighttime drone visual landing spotlight is too bright, making it impossible to recognize the QR code."

"Temperature and humidity caused burnout, resulting in D135 returning to center and charging, and 485 going offline."

The value of this type of checklist lies not in the "problem" itself, but in the fact that it demonstrates three points: first, the HEISHA modular architecture was iterated through under the guidance of real-world failures rather than through laboratory simulations; second, the problems span eight engineering domains — power supply, thermal management, transmission accuracy, charging compatibility, concurrent operation of multiple devices, sensor reliability, material sealing, and software stability — demonstrating that verification has reached every corner of the system; third,

organizations that dare to list failure records in their external documentation generally provide more credible reliability data than organizations that present only successful cases.

8.7.2 Issue Distribution (categorized by engineering domain)

Engineering Domain	Representative Issues	Design improvement directions
Power Supply and Power Matching	ACK150 voltage instability causes charging failure; insufficient external power supply to D135; insufficient 12 V power supply within T3; D250 trips upon power-on; 485 offline (low power supply voltage causes DCAP V3 to operate abnormally)	Power budget margin and power supply link voltage drop calculation
heat management	Excessive power consumption in high-current switches / LDO overheating; ACK temperature too high, resulting in failure to operate normally; D250 Raspberry Pi overheating; D250 air conditioner has insufficient airflow	Power device thermal design and airflow duct design
Return centering and transmission accuracy	DCAP centering screw has a deviation in coaxiality; DCAP V3 centering lift mechanism has a derailment; centering lock rod; centering release fails to stop; D250 pusher motor experiences step loss; D135 centering motor fails to push	Transmission chain stiffness, coaxiality manufacturing processes, limit positioning and force control
Charging compatibility	M4E fails to shut down and charge properly; the unstable M400 switchable version prevents charging; ACK800 is prone to burnout; ACK2000 produces no output during charging; D135 displays a "battery certification failed" message when charging upon startup.	Battery protocol compatibility and selection of charging circuit components
Multi-device concurrency	When the DCAP remote controller and the drone are charged simultaneously, the entire unit shuts down; when charging the DCAP V3 M4E, the device cannot be released from the centering position while charging, and the charging station goes offline simultaneously.	Power and Communication Resource Allocation under Concurrent Operating Conditions
Sensor reliability	Rainfall count does not reset to zero; temperature and humidity damage causes the 485 module to go offline; the network RTK fails to connect automatically; the base station RTK cannot remain in standby for an extended period; the DJI remote control cannot remain in standby for an extended period and cannot determine whether it is powered on.	Sensor Protection, Power Supply, and Watchdog Design
Materials and Sealing	Material rusting; D250 leakage; the upper cover scrapes the inner side of the support leg during drum operation	Corrosion protection selection, sealing structure, and operating clearance
Software Stability	HSC cloud entry process crashes; DJI PILOT fails to start normally; DJI RC Plus remote control occasionally fails to power on; M4E frequently powers on and off during charging or occasionally fails to start; D135 motor triggers an alarm, followed by a false detection of the lid being open	Software exception handling and state machine robustness

8.7.3 The most critical gap: lack of solutions

The original entries for the approximately 70 records listed above contain only problem descriptions and do not include solutions, root cause analyses, or corrective actions. This document summarizes common corrective approaches based on engineering logic (see 9.9.2); it does not provide a final solution on behalf of HEISHA. The individual rectification records constitute internal technical documents and will be compiled separately.

This list currently represents "half the assets" —it demonstrates the authenticity and scope of the issues, but it does not prove how HEISHA can resolve them. For integrators, "having encountered this issue" and "this issue has been systematically resolved" are two entirely different pieces of information.

Each issue should be documented as a three-part record: issue manifestation → root cause analysis → corrective actions and verification. This represents the highest return on investment among all existing supplementary work for HEISHA: the data already exists (the issue list); only the analysis and corrective actions need to be completed, enabling an internal fault record to be transformed into the most persuasive proof of engineering capability in the white paper. It is recommended that this item be prioritized as P0.

8.8 Factory Inspection and On-Site Acceptance: Recommended Framework

The comprehensive specifications for factory inspection and on-site acceptance shall be issued by Heisha on a project-by-project basis. This section provides a recommended framework that may serve as a checklist for technical review or be replaced by the specifications actually implemented.

8.8.1 Recommended factory inspection items

kind of inspection	Recommended test items	Basis for Determination
structure	Door opening and closing action, full travel, limit trigger, and sealing surface contact	All limit switch status bits (Bit0: limit open / Bit1: limit closed) have been triggered correctly.
structure	Return-to-center movement, two-stage locking (LOCKING_STEP1 / LOCKING_STEP2), release	The return-to-center state machine exhibits no FAULT across the entire sequence.
electrical	Insulation resistance, grounding continuity, voltage	GB 4943.1 / EN 62368-1

kind of inspection	Recommended test items	Basis for Determination
	withstand capability	corresponding clauses
electrical	Output voltages across various voltage ranges (24 V/12 V/5 V expansion ports), charging output voltage and current	The deviation between the register reading of the physical model and the nominal value is within the permissible tolerance.
control	Full instruction traversal (cover/putter/charge/air-conditioner/alarm, etc.)	services_reply returns result=0, progress=100%, and status=ok
control	Event reporting traversal (INFO/ERROR/ALERT, each injected once)	The events message encoding and bit mask are correct.
communication	MQTT connection, OSD fixed frequency 0.5 Hz, state change reporting	Message frequency and content comply with the protocol definitions.
communication	Resume running after a network outage (T100 comprehensive command)	Batch processing commands continue to execute during network outages; data will be resent after the system goes online.
environment	Temperature control start threshold, constant temperature range, and anti-condensation logic	Cabin temperature is maintained within the preset range.

8.8.2 Recommended on-site acceptance procedure

stage	Recommended content
Installation Inspection	Foundation/fixing method complies with the design (expansion bolts / drill-free brackets / roof luggage racks / lifting rings); levelness; grounding
No-load commissioning	Full instruction traversal + event traversal; integration and joint debugging with the cloud platform (including a joint debugging checklist, see Chapter 7, Section 7.9)
Load-bearing integration testing	Actual drone deployment: alignment accuracy during return to base, charging contact reliability, power-on/off sequence, and the one-touch flight readiness workflow
continuous duty	It is recommended that continuous unattended operation be conducted for no less than 72 hours, with the success rate and number of alarms recorded.
Environmental Spot Checks	On-site measurement of whether the cabin's temperature and humidity are maintained within the specified range; for the rainy season and wind season tests, additionally observe exposure to rain and wind resistance.
Document Handover	Drawings, BOM, API documentation, physical model and register mapping tables, test reports, O&M manuals, and spare parts lists

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8.9 Assessment of Reliability Evidence Completeness and Priority for Supplementation

8.9.1 Overall Assessment of Honesty

dimension	Status of Evidence	appraise
quality management system	☑ Valid ISO 9001 certification, covering R&D + production	complete
Electrical Safety and EMC	☑ CCC + CE + FCC + Two Pass	complete

dimension	Status of Evidence	appraise
	Test Reports	
hazardous material	The RoHS report has been submitted for review; the conclusion page is pending verification.	Basically complete; the conclusion page needs to be added.
Structural strength (container configuration)	☑ Class Society Container Certificate (holder: CIMC)	The cabinet level is complete; the overall machine level remains to be confirmed.
levels of protection(IP)	Only the product's self-reported value; the current IP54 certification does not apply to this product.	**breaking point**
Environmental adaptability (temperature/salt spray/dust/wind and rain)	Design parameters are comprehensive; laboratory reports are pending completion.	**breaking point**
Service Life and Durability	DCAP MINI ≥ 5,000 hours is the self-reported value	**breaking point**
Field Engineering Experience	☑ Approximately 70 verified question records	**The problem side is complete, while the solution side has a breakpoint.**
Certificate Validity Period	CCC valid until 2026-09-29	Confirmation of certificate renewal is required
Model coverage	Compatible with the D60/D80/D135/DNEST/DCAP series	New-generation products awaiting supplementary certification

8.9.2 Recommended supplementary seniority

Sort by "Impact on Integrator Decision-Making × Additional Cost":

priority	Supplementary Item	Reason
P0	"Technical Issues to Be Resolved": Root Causes and Mitigation Measures Added Item by Item	The data already exists; simply complete the remaining entries. This is the most reliable and persuasive form of incremental improvement.
P0	Third-party IP protection rating test report (for products with each specified rating)	The existing IP54 certificate applies to another product and must be replaced.
P0	CCC Certificate Renewal Status Confirmation	Timeliness issues affect the accuracy of compliance statements
P1	High and Low Temperature, Salt Spray, Sand and Dust, and Rain Exposure Test Reports	Supports all environmental claims in Chapter 5
P1	Service life/durability cycle test data	Estimation of O&M costs for unattended scenarios
P1	Compliance certificates for next-generation products (D65/D90/D200/D250, energy storage cabinets, etc.)	The current range of certificate models is incomplete.
P2	Wind resistance test or structural wind load calculation report; snow load calculation report	Structural claims supporting D65/D90
P2	Vehicle Vibration/Impact Test Report	Supporting the reliability claims for the in-vehicle series
P2	RoHS report conclusion page and wireless module certification status	Address compliance details

8.9.3 Recommendations for Integrators on Acceptance

Prior to completing the above-mentioned requirements, the integrator may accept HEISHA's reliability information based on the following principles:

1. Electrical safety and EMC compliance can be directly accepted—supported by Pass reports from CNAS-accredited bodies and CCC/CE/FCC certifications.

2. At the environmental adaptability level, the approach is to accept the design on the basis that it is "designally credible, with verification to be completed": the design parameters and structural solution are complete and internally consistent, but they should be regarded as design commitments rather than as verified indicators; in the contract, key environmental indicators (operating temperature, protection rating, wind resistance) may be stipulated as acceptance criteria, with verification to be completed through on-site measurement.

3. At the service-life level, it is recommended that on-site operating records for products of the same type be provided; the delivery history for HEISHA in the 8-year and 12+ configurations indicates that on-site data is highly likely to exist, although it has not yet been incorporated into the existing documentation.

4. Focus on concurrent operation across multiple devices and power supply matching—based on the distribution of the problem list, these two engineering domains are areas where historical failures are concentrated; they should therefore be treated as key validation items in customized projects (see Chapter 9, Section 9.9 for details).

All certificate numbers, standard numbers, dates, and model numbers in this chapter have been transcribed verbatim from images in the existing materials (image75 – image83). Fields that are blurred or unrecognizable in the images have not been inferred; the relevant omissions are summarized in Appendix E.

Charpter 9 Customized Delivery Methodology

9.1 The genuine pain points of customized projects

Custom drone hangar projects generally face three core pain points:

pain spot	Performance	source

pain spot	Performance	source
cycle length	The process from requirements confirmation to delivery often takes several months.	Each order is redesigned from scratch, resulting in a lack of modular reuse.
High cost	Customization costs far exceed those of standard products.	Information asymmetry leads to repeated communications and changes to plans.
Reliability is uncontrolled	Field failures occur frequently, keeping O&M costs persistently high.	Inconsistent interfaces, insufficient test coverage, and inadequate environment compatibility

The underlying root cause of these pain points lies in information asymmetry: customers do not know what requirements they need to specify (thereby overlooking critical constraints), while suppliers do not understand the customers' actual operating scenarios (designing based on nominal parameters rather than actual operating conditions). Each project requires communication, design, and validation from scratch, making it impossible to build reusable engineering expertise.

Heisha's approach to addressing these challenges is reflected in three dimensions: -Modularization (see Chapter 3): dividing the cabin, transmission, electrical systems, and control systems into configurable standard modules; -Standardized interfaces (see Chapter 7): a unified MQTT device model and MODBUS register mapping; -Structured requirement input (the core of this chapter): transforming "what the customer wants" into a fillable and verifiable requirements list.

The objective of this chapter is to provide a ready-to-use toolkit of delivery methodology tools that helps integrators and client-side engineers establish a clear requirements baseline at the project initiation stage, thereby reducing later-stage changes and rework.

9.2 Requirements Input Request (RFI)

9.2.1 Source of the List and Instructions for Use

The following RFI (Request for Information) checklist is developed in full based on the nine major categories outlined in the FAQ "Key Considerations for Customizing the HEISHA Mining Library." Each item includes: the requirement, optional values/entry instructions, why it is important (which design decision it affects), and the consequences of omitting it.

This checklist has been compiled based on engineering practice and incorporates common omissions found in the FAQ; it serves as a recommended framework. HEISHA

may adjust its format and content according to its own processes.

9.2.2 Basic Specifications

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
Closed-loop dimension limit	Length × Width × Height (mm), including transport restrictions	Determine the hull geometry and transportation method	May exceed the maximum transport height or installation space requirements.
Expand size restrictions	Length × Width × Height (mm), including safety clearances	Determine the lid-opening method and the return-to-center mechanism stroke	May interfere with surrounding facilities
weight restrictions	Maximum total unit weight (kg)	Determines material selection and structural strength	May exceed the lifting/handling capacity
Material preferences	□ Aluminum alloy □ Carbon fiber composite □ Stainless steel □ Glass-fiber composite □ Galvanized steel sheet □ ABS+PVC □ Teflon □ Others	Affects the protection rating, corrosion resistance, weight, and cost	Default material selection may not meet environmental requirements.

9.2.3 Structural Transmission and Deployment Design

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
Opening method	□ Flip cover □ Lift cover □ Side-opening □ Other	Determine the type of door actuation mechanism and the sealing design	The default configuration may not be suitable for the installation space.
Is there a lifting mechanism?	□ Yes □ No	Affects the cabin height and apron position	—
Return-to-center method	□ Gravity centering □ Pusher centering □ Turntable centering	Determining the complexity and precision of the regression algorithm	High failure rate in returning to the center
External Design Requirements	Free description (e.g., color, markings, appearance style)	Affects sheet metal dies and spray coating processes	The default appearance may not meet Party A's requirements.
T3: Concomitant or isolated	□ Combined (T3 integrated within the hangar) □ Separated (T3 with independent control station)	Determine the electrical layout and cable routing	Installation space mismatch
Vehicle considerations	□ Not required □ Shock resistance required □ Dynamic orientation compensation required	Determine the shock-absorption mechanism and reinforcement design	Vehicle-induced vibration causes equipment damage
Deployment method	□ Forklift □ Crane □	Determine the base structure and the design of the	Cannot be installed on-site

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
	Wheel mobility □ Installation of an aluminum alloy base □ Concrete fixation □ Cabin integration	lifting points	
peripheral interface	□ Emergency stop button □Other ___	Security and Compliance Requirements	Lacks necessary security interfaces

9.2.4 Environmental adaptability requirements

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
Minimum operating temperature	___℃	Determine the heating scheme and battery thermal management strategy	Unable to start or charge at low temperatures
maximum working temperature	___℃	Determine the refrigeration scheme and heat dissipation design	High-temperature overheat protection shutdown
Salt spray rating	□None □C3 □C4-M □C5-M □Other	Determine the materials for the anti-corrosion coating and fasteners	Short-term corrosion in coastal environments
Dust-proofing requirements	□ Standard □ Fully sealed □ Teflon-opened component	Determine the sealing structure and the material of the opening component	Dust ingress causing equipment wear
IP grade	□IP54 □IP55 □IP64 □IP65 □Other	Determine the sealing process and testing standards	Inadequate protection leads to the ingress of water and dust.
Lightning protection device	□ Not required □ External lightning rod □ Surge protector □ Both required	Determine the lightning protection and grounding design	Equipment damaged by lightning strike
Air conditioning mode	□Compressor □Semiconductor □Fan □PTC Heating □Combination	Determine the power and size of the temperature control system	Insufficient temperature control capability
Air conditioner power	___W	Determine the power supply capacity	Insufficient power makes it impossible to maintain a constant temperature.
control method	□ Automatic □ Manual □ Remote	Determine the complexity of the control logic	—
Temperature acquisition method	□ Single point □ Multiple points (___ routes)	Determines temperature control accuracy and zoning capability	Local overheating/undercooling
Heating method	□ PTC □ Heat pump □ Electric heating □ Others	Determines heating efficiency in extremely cold environments	Slow temperature rise at low temperatures
air duct design	□ Natural convection □ Forced	Determine the fan layout and noise level	Uneven heat dissipation

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
	air cooling □ Directional air supply		
Fan Design	□ Quantity: ___ □ Adjustable speed □Redundancy	Determines heat dissipation capacity and reliability	Single-fan failure causing overheating

9.2.5 Intelligent components

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
Surveillance camera	Quantity_; Position: □ Inside the warehouse □ Outside the warehouse; Angle_	Determine the camera model and installation location	Monitoring blind spots
Weather sensor	□ Six key elements □ Simplified configuration (wind speed + rainfall) □ Not required	Determine the type and interface of the weather station	Lack of critical environmental data
Acoustic and visual alarm	□ Required □ Not required	Determine the selection of the alarm and its triggering logic	No on-site alarm notification
status lamp	□ RGB tri-color lights □ Monochromatic lights □ Not required	Determine the lighting control and wiring	Status cannot be determined remotely
Temperature and humidity sensor	□ Inside cabin □ Outside cabin □ Both	Determine the precision of the temperature control closed loop	Significant temperature control deviation
fire-fighting equipment	□ Fire extinguisher □ Others ___ □ Not required	Determine the design and compliance of the fire protection system	security risk

9.2.6 Power Supply Management

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
input voltage	□ AC110V □ AC220V □ DC24V □DC48V □Other	Determine the power supply module selection	Power supply mismatch
postpositionUPS	□ Not required □ Required (capacity ___ Wh)	Determine power-off protection and battery life	Data loss or equipment damage due to unexpected power outage
Front-mounted UPS	□ Not required □ Voltage regulation □ Power regulation □ Boost	Ensure power supply quality	Voltage fluctuations cause equipment malfunctions
Solar photovoltaic panels	□ Not required □ Required (power ___ W)	Determine the off-grid power supply capacity	Cannot operate without access to grid power outdoors.

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
Power status reporting	□ Required □ Not required	Determine the power monitoring module	Power supply status cannot be determined remotely.
Power Failure Reporting	□ Required □ Not required	Determine the alarm link	Power supply faults cannot be detected in a timely manner

9.2.7 Charging Management

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
Charging power	___W	Determine the selection of the charging module and the power supply capacity	Slow charging speed or insufficient power
charging current	___A	Determine electrode and cable specifications	Overcurrent burnout
security guard	□ OVP □ Undervoltage □ OCP □ Anti-backflow protection □ Anti-over-discharge protection □ Temperature monitoring	Determine the protection circuit design	Battery safety incident
Power On/Off Function	□ Required □ Not required	Determine the function of the charging module	Unable to remotely control the drone
Switching board	□ Not required □ Required (Model: ___)	Determine a multi-model compatibility solution	Hardware must be replaced when switching between device models.
Contact charging stability	Transmission accuracy requirements for return	Determine the alignment accuracy between the centering device and the electrodes	Poor charging contact
compatibility	List of compatible device models	Determine charging stand and protocol compatibility	Unable to charge

9.2.8 communication

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
Primary communication method	□ 4G □ 5G □ RJ45 Ethernet □ STARLINK □ Private Network	Determine the selection of the communication module	Internet connection unavailable
Redundant communication	□ Not required □ Dual 4G □ 4G + Ethernet □ Other	Determines communication reliability	Single-link failure and loss of connectivity
Communication handover	□ Automatic □ Manual	Decision to switch logic	Unable to automatically recover when a fault occurs
Signal strength reporting	□ Required □ Not required	Decide on antenna monitoring	Communication quality cannot be predicted

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
router	□ Self-provided □ Provided by Heisha	Decide on network equipment integration	Difficulties in on-site network configuration

9.2.9 UAV-assisted

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
Charging stand	□ Standard □ Customized (Model ___)	Determine the charging contact position	Charging failed
Battery modification/switching board	□ Not required □ Required (Model: ___)	Determine a multi-model compatibility solution	Battery replacement requires manual intervention
Remote control base	□ Not required □ Single workstation □ Dual workstation	Configure remote control storage and remote control	The remote control cannot be used to turn the device on or off remotely.
Base station RTK assistance	□ Not required □ Built-in base station □ External base station	Determine the precision of the precision landing	Significant landing deviation

9.2.10 Interfaces and Documentation

Requirements	Optional Values / Filling Instructions	Why is it important?	Consequences of not completing it
Interface Protocol	□ MQTT □ MODBUS RTU □ MODBUS TCP □Other	Determine the cloud platform integration method	Protocol mismatch
Video streaming	□RTMP □RTSP □Not required	Determine the video link	Cannot be viewed in real time
State reporting completeness	□ Full Perception □ On-Demand Tailoring	Determine sensor configuration and bandwidth	Critical state missing
APID	□Required □Already Available	Decision and Preparation for Development	Development delay
HSCsoftware	□ Purchase source code □ Not required	Determine the starting point for secondary development	Zero-based development incurs high costs.
DNESTterrace	□ Purchase source code □ Not required □ Build in-house	Determine the scheduling platform solution	Platform development cycles are lengthy
HSC operating computer	□ Self-provided □ Provided by Heisha	Decide on hardware procurement	Operating environment mismatch

9.2.11 Recommended additional requirements

The following requirements are not listed in the FAQ, yet they frequently become project risk points in engineering practice:

Requirements	Instructions for Completion	Why is it important?

Requirements	Instructions for Completion	Why is it important?
Project Volume and Delivery Pace	First batch: _ units; subsequent batch: _ units/month	Affects production scheduling and the allocation of mold investment
Installation site requirements	Load-bearing capacity ___ kg/m ², foundation type, and width of accessways	Influence on deployment method and lifting plan
Local Laws and Compliance Requirements	Airspace approval, electromagnetic compatibility, and fire safety	Affects certification and acceptance
acceptance level	Functional test items, performance indicators, and reliability testing	Affects testing plans and deliverables
Operations and Maintenance Capabilities and Spare Parts Strategy	Customer self-operation and maintenance / Heisha O&M; spare parts inventory requirements	Influence on after-sales service solution design
life expectancy	___year	Influence on material selection and reliability design
Noise limits	___dB (Whether there are residential areas near the installation location)	Influences the selection of fans and air conditioners
Electromagnetic Compatibility Requirements	□ No special requirements □ Must pass the ___ standard test	Impact on shielding design and certification

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9.3 Model Selection Decision Process

9.3.1 The derivation chain from RFI to configuration

flowchart TD

A[Determine the type and dimensions of the UAV] --> B{Requirements for internal cabin dimensions}

B--> C{Select size range}

C-->|Small| D1 [D65/D80 series]

C-->|Medium-sized| D2 [D100/D135 series]

C-->|Large| D3 [D200/D250 series]

C-->|Special-purpose| D4 [D90/D330/V200/DCAP, etc.]

D1 & D2 & D3 & D4--> E{Gate operation mode}

E-->|Flap| F1 [Standard Flap]

E-->|lift| F2[Lift type]

E-->|Side-opening| F3[Side-opening type]

F1 & F2 & F3--> G{Regression method}

G-->|Gravity| H1[Gravity Returns to Center]

G-->|Push rod| H2[Push rod centering]

G-->|Spin Wheel| H3 [Spin Wheel Centering − Specifically for Vertical Lift]

H1 & H2 & H3--> I{Is dynamic functionality required?}

I-->|is| J1 [paddling/airspeed tube/anchoring, etc.]

I-->|No| J2[Standard Configuration]

J1 & J2--> K{Environment Package Selection}

K-->|room temperature| L1[standard environment package]

K-->|Extreme Cold| L2 [PTC Heating + Three-Stage Temperature Control]

K-->|Ultrafine Dust| L3 [Fully Sealed + Teflon]

K-->|Coastal| L4[C4-M corrosion protection + salt spray protection]

K-->|Composite Extreme| L5 [Full Level D90 Protection]

L1 & L2 & L3 & L4 & L5--> M{Power Supply Scheme}

M-->| mains power | N1 [direct AC220V supply]

M-->|Mains power + UPS| N2[AC220V + UPS]

M-->|Off-grid PV| N3 [PV + Energy Storage]

M-->|Vehicle DC| N4[DC24V]

N1 & N2 & N3 & N4--> O{Communication Scheme}

O-->|Public Network| P1[4G/5G]

O-->|wired| P2[RJ45 Ethernet]

O-->|Satellite| P3[STARLINK]

O-->|Dedicated Network| P4 [Dedicated Network Module]

P1 & P2 & P3 & P4--> Q{Intelligent Customization}

Q--> R [Configuration Checklist Completed]

Figure 9-1 Selection Decision Tree

9.3.2 Example of Key Criteria

ambient condition	Recommended Configuration	according to
Operating temperature <-20 °C	PTC heating + three-stage temperature control + low-temperature battery solution	D90 Performance: −40 °C to +65 °C, ±3 °C accuracy
Coastal/Island deployment	C4-M corrosion resistance + customized salt spray resistance + stainless steel fasteners	D90 Performance: C4-M High Anti-corrosion Grade
Mining area dust / desert airborne dust	IP65 + fully sealed + PTFE access components	D90 Field Test: Fully Sealed Multi-stage Dust Protection
In-vehicle deployment	Automotive-grade main controller + shock-proofing + DC24V power supply	DCAP MINI Case Study: Automotive-grade Main Controller and Automotive Terminal Wiring Harnesses
Downward-fixed-wing aircraft	Spin-off centering + free-flow tube air blowing + pitch mechanism	D330/V200 Validation: Dedicated Lifting Command
Logistics transfer	Multi-compartment management + robotic arm + loading/unloading commands	API physical model: locker_door_state / machine_arm
Portable/Fast Deployment	Rolling suitcase style + built-in battery + gravity-based centering	D007: Empirical test − 45 kg; built-in battery standby time: 5 h

The large/medium/small size categories are defined according to the quantitative criteria specified in 2.3.3: the primary criterion is compatibility with the drone's takeoff and landing envelope (the larger of the landing gear outer dimensions and the unfolded blade diameter); the net opening dimensions of the fuselage are used for verification; and boundary-case models are rechecked by Heisha using the module atlas.

9.3.3 Configuration List Expression Paradigm

It is recommended that a complete solution be described using a combination of MD/JD/ND codes, an environment package, and optional components. For example:

D90-MD01-JD03-ND05 + ENV-EXTREME-COLD + OPT-SOLAR + OPT-SATCOM

```
| | | | | | |
| | | | | | └─ Satellite Communication Module
| | | | | └─ Off-grid Photovoltaic Energy Storage System
| | | | └─ Extreme Cold Environment Kit
```

│ │ │ └─ Actuation Module 05 (Paddle Receptacle)

│ │ └─ Drive Module 03 (Push Rod Centering)

│ └─ Door Movement Module 01 (Flip Cover)

└─ D90 Extreme Cold & Extreme Dust Hangar Base Model

The codes provided above are for illustrative purposes; the complete coding table is provided in Appendix A. The code values specified in the configuration list shall be subject to those set forth in Appendix A and the configuration list issued by Heisha.

9.4 Project Milestones and Deliverables

9.4.1 Recommended Milestone Breakdown

The following milestones constitute a recommended framework, compiled based on industry-standard practices and the deliverables that can be substantiated for HEISHA; the specific project processes and milestones shall be subject to the project schedule stipulated in the contract.

stage	main activity	deliverable	Empirical evidence
Requirement Confirmation	RFI completion, requirements review, and configuration order confirmation	Requirements Specification, Configuration List	Chapter RFI Checklist
conceptual design	Overall Plan, Interface Definition, Preliminary BOM Draft	Solution manual, interface documentation	"The drawings and BOM have already been finalized."
detailed design	Structural design, electrical design, and software integration	Detailed drawings, BOM, and wiring diagrams	Product Packaging List
Prototype/First Article	Prototype manufacturing and functional verification	Prototype, Test Report	"Reliability test report issued by a third-party organization" (referenced in D80/D135)
Testing and Validation	Environmental testing, reliability testing, and integrated commissioning	Test report, issue list	Stability test images (image75/76)
volume production	Mass production, quality inspection, and packaging	Finished product and factory inspection report	—
field installation	Installation, commissioning, and training	Installation records and training records	VIP after-sales service includes "one on-site training session"

stage	main activity	deliverable	Empirical evidence
check and accept	Functional acceptance and performance acceptance	Acceptance Report	—
operation	Remote monitoring, regular maintenance, and fault resolution	Operations and Maintenance Records	Q100 V2.0 and DNEST operational maintenance features

9.4.2 List of deliverables for verification

Based on the packaging lists and document delivery status for each product:

deliverable	source	remarks
Hangar structure	Complete Product Packaging List	—
T3 control pole (where applicable)	D80 Packaging List	Some products: T3 consolidation
T3 Tool Kit	D80 Packaging List	On-site maintenance tools
RJ45 Ethernet connector	D80/D330 Packaging List	LP24-RJ45
Power cord (including power adapter)	D330/V200 Packaging List	Configure according to order specifications
PDAdebugging aid	D330/V200 Packaging List	Medical-grade standard
Maintain the door key	D330/V200 Packaging List	—
Drone charging tripod kit	D330 Packaging List	Non-destructive installation
audible and visual alarm	D80 Packaging List (Optional)	—
Remote control base	D80 Packaging List (Optional)	—
APID	Heisha Ruyun API Documentation	Approximately 22,000 lines, 30 version iterations
Physical Model and Register Mapping Table	APID	Complete definition of properties/methods/events
HSCsource code	For example, when purchasing	Direct delivery of source code
DNEST source code	For example, when purchasing	Direct delivery of source code
Visual SDK AAR + QR Image PDF	For example, when purchasing	AAR Binary + PDF Fixed Images
test report	D80/D135 mentions "reliability test reports issued by third-party institutions."	D80/D135: With regard to third-party reliability test reports, the report details are provided in Appendix E.
Operations and Maintenance Manual	—	The O&M manual shall be delivered with the project.

Quantitative data on cycles and costs are determined on a project-by-project basis; this document does not specify particular numbers of days or amounts; the influencing-factor framework is provided in Section 9.5.

9.5 Cycle and Cost Impact Factors

This section provides a qualitative framework and does not include quantitative

cycle or cost data; specific values shall be determined in accordance with the change level specified in Section 2.5.4 and the approved project schedule.

9.5.1 Impact of Customization Levels and Cycle Times

Customized hierarchy	description	Cyclical impact	instance
Zero modifications	Select the hardened module + standard environment package	Shortest (based on standard configuration scheduling)	Standard D80 + standard accessories
Parametric adjustment	Size range adjustment, stroke adjustment, and color change	Shorter	D135: Color change and fine-tuning of the centering travel
Module-level addition	New transmission methods, new active functions	secondary	Add a new oar mechanism and a new mooring module
System-level customization	Brand-new form, brand-new environment package	longest	Containerized, suitcase-style, indoor unit storage

9.5.2 Cost Impact Factor

factor	Low-cost segment	High-end segment	explain
Module maturity	Solidified mass-production module	Newly developed module	Mold amortization and validation costs
Material grade	ABS+PVC	Carbon fiber composite / stainless steel / Teflon	There are significant variations in raw material and processing costs.
levels of protection	IP54	IP65	Increasing costs associated with sealing processes and testing
Corrosion resistance rating	Standard spraying	C4-M/C5-M	Coating system and fastener material
Temperature control configuration	electric fan	Compressor air conditioner + PTC + 1.5 HP air conditioner	Rising equipment costs and power consumption
Power Supply Plan	Direct municipal power supply	Photovoltaic energy storage off-grid + UPS	Battery pack and inverter costs
Communication Solution	RJ45 Ethernet	satellite communication	Module costs and fees
Intelligent Configuration	not have	Full suite (camera + weather station + fire protection + AI)	Sensor and software licensing costs
Certification Requirements	not have	CE/FCC/RoHS + Classification Society	Testing fees and certification fees

9.5.3 The Impact of Quantity on Cost

Based on general principles, the impact of quantity on cost is inferred; the specific data for this study, excluding quantity discounts, are as follows:

The cost of the first unit/sample typically exceeds that of batch production (inferred; the multiplier is determined based on process requirements and mold investment).

Mold and tooling costs can be amortized once batch volumes reach a certain

threshold; the amortization threshold depends on the mold type and the procurement batch size (inferred).

Software adaptation costs are independent of the quantity and constitute a one-time investment.

9.6 Production and Supply Chain Capabilities

The production capacity information discussed in this section (production lines, capacity, delivery cycles, and supply chains) constitutes commercial data; no inferred values are provided in this document, and the relevant entries are listed in Appendix E.

9.6.1 present situation

The "Production Capacity" section contains only one factory photo and one factory video link.

There are no quantitative data regarding production capacity, site area, equipment inventory, personnel headcount, or delivery lead time.

9.6.2 Information that can be inferred indirectly

Product specifications and material descriptions allow for the following indirect inferences: -The product materials include aluminum alloy, carbon fiber composite, stainless steel, glass-fiber composite, galvanized steel sheet, ABS+PVC, and Teflon → the company has processing capabilities for a variety of materials; -D100 is marked as "standard production inventory: 0 sets" → the company has an inventory management mechanism; -The product line covers more than 12 product forms → the company possesses a certain level of flexible production capacity.

9.6.3 Collaboration leads

Patent 2025104790318 (CN120229407A), "Drone Hangar, Hangar Control System and Hangar Control Method," was jointly applied for by "Guangdong Xinhui CIMC Special Transport Equipment Co., Ltd., Midum International Marine Containers (Group) Co., Ltd., and Shenzhen Heisha Technology Co., Ltd."

The joint application itself indicates that HEISHA and CIMC Group have a technical cooperation relationship; the scope and content of this cooperation are not set out in the present document, and readers may make their own assessment based on the joint patent

and the V200 product form.

9.6.4 Recommended additional information checklist

item of information	explain	priority
Production site area	Total area; area of each functional zone	High
Number of production lines	Assembly lines, testing lines, painting lines, etc.	High
Monthly production capacity	Monthly production volume of standard and customized products	High
Key processing equipment	Equipment inventory: CNC, sheet metal fabrication, welding, painting, and other equipment	Midum
staff composition	R&D/Production/Quality/After-sales personnel	Midum
Quality Team Size	QC/QA personnel and testing equipment	Midum
Typical delivery cycle	Lead times for standard products / parametric adjustments / system-level customization	High
Spare Parts Inventory Strategy	Common spare parts inventory levels and replenishment cycles	Midum
Supply Chain Resilience	Number of key component suppliers and alternative solutions	low

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9.7 Qualification Certification and Compliance

9.7.1 Current Qualifications and Certification List

The system certification, product compliance, and third-party testing evidence for HEISHA have been verified item by item in Chapter 8 and are summarized as follows:

class	Certificate/Report	state
system certification	ISO 9001 Quality Management System (Reference No.04626Q00310R001)	☑Valid; expiration date: 2029-01-19
Product Compliance	CE Conformity Declaration (EMC Directive 2014/30/EU + LVD 2014/35/EU)	☑Already available
Product Compliance	FCC Compliance Statement (47 CFR Part 15 Subpart B)	☑Already available
Product Compliance	CCC Compulsory Product Certification (No.2021010907421117)	Valid until 2026-09-29; the renewal status is provided in Appendix E.
Product Compliance	RoHS Test Report (NTEK, 309 pages)	Report: 309 pages; the conclusion page is provided in Section 8.3.4.
Third-party testing	GRGTEST EMC Immunity and Emission (EN 61000-6-2 / 6-4)	☑Conclusion: Pass
Third-party testing	GRGTEST Safety Testing (EN 62368-1)	☑Conclusion: Pass
ship classification society	Midum Classification Society container certificate (No. GTD24S4332)	The certified object is the nacelle; full aircraft certification for the hangar may be applied for on a project-by-project

class	Certificate/Report	state basis.

Key gap: The range of tested models covered by the aforementioned certificates and test reports does not encompass the entire product line. The number of models confirmed to be covered is limited; the compliance status for the D65, D90, D200, D250, D330, V200, D007, DCAP PRO/MINI/LITE/INBUILT, energy storage cabinets, and the ACK series has not yet been certified, and these items are listed individually in Appendix E.2. For details, see Section 8.1.2.

Furthermore, there are currently no third-party test reports for the IP protection ratings: although the product parameters specify IP54/IP55/IP64/IP65, the only existing IP54 compliance statement found in the available documentation has been verified to pertain to a different product; therefore, it cannot serve as evidence of the protection rating for the Heisha product (see Section 8.5.2).

9.7.2 Certification clues scattered throughout product specifications

Certification/Level	Source Product	concrete content
CE/FCC/RoHS	D80、D135	"CE/FCC/RoHS (export model)"
Third-Party Reliability Test Report	D80、D135	"Reliability test report issued by a third-party institution" (report contents not provided)
IP54	D80/D135/D200/DCAP/DCAP MINI/DCAP LITE/ACK2000	Product Specifications Table
IP55	D65 Hangar Main Structure	Product Specifications Table
IP64	Energy storage cabinet	Product Specifications Table
IP65	D90	Product Specifications Table
IP65 (enhanced protection)	D65	"Supports customization for a higher protection rating (IP65)"
Explosion-proof version	D65	"Supports customization... explosion-proof version"
Altitude acclimatization	ACK2000	≤ 3000 m; beyond this limit, the power rating must be reduced, with power decreasing by 10% for every 1000 m increase in altitude.
Medical-grade testing	PDAdebugging aid	EMI radiation, high and low temperatures, microwave interference, coil interference, and burst pulses
Class Society Certification	colophon	"Class Society certification updated on 2025.08.06" (details are provided only in the form of images)
Related Certification Updates	colophon	"Updated HEISHA-related certifications on 2025.07.20" (details not provided)

9.7.3 Summary Table of Known Certification and Level Information

product	IP grade	antiseptic	temperature range	Certification lead	remarks
D65	IP55 (customizable to IP65)	—	-20℃~+55℃	Explosion-proof version supported	—
D80	IP54	—	-20℃~+55℃	CE/FCC/RoHS (export models); third-party reliability test report	—
D90	IP65	C4-M	-40℃~+65℃	—	Snow load ≥ 120 kg/㎡
D135	IP54	—	-20℃~+55℃	CE/FCC/RoHS (export models); third-party reliability test report	—
D200	IP54	—	-20℃~+55℃	—	—
D330	IP54	—	-20℃~+55℃	—	—
V200	IP54	—	-20℃~+55℃	—	Containerized design
DCAP	IP54	—	—	—	—
DCAP MINI	IP54	—	0℃~+55℃	—	Heating module available as an optional option
DCAP LITE	IP54	—	—	—	—
ACK2000	IP54	—	—	Elevation ≤ 3,000 m	Over 3,000 m: derate by 10% per 1,000 m
Energy storage cabinet	IP64	—	—	—	—
PDA	—	—	—	Medical-grade EMI / High/Low Temperature / Microwave / Group Pulse Testing	—

9.7.4 Recommended list of additional certification information

item of information	explain	priority
ISO 9001 Certificate Number	Issuing authority, validity period, coverage	High
CE Certificate Number	Applicable product models and scope of application	High
FCC Certification Number	Applicable product models	High
RoHS Test Report	Testing Agency and Report Number	Midum
Third-Party Reliability Test Report	Testing organization, test item, test result, report number	High
Class Society Certification Details	Certification Authority, Applicable Scenarios, Certificate Number, Validity Period	High
IP Rating Test Report	Testing organization, testing method, and testing results	Midum
Explosion-proof certification	Certification body, explosion-proof rating, applicable products	Medium (if applicable)
Stability Test Details	Test conditions, duration, pass criteria, test results	Midum

9.8 After-sales and Operations & Maintenance Support

9.8.1 HEISHA General After-Sales Policy Terms

Key Clause Extraction:

clause	content
response time	Response and feedback within 24 hours
defects liability period	One year of free maintenance service
Supplementary Maintenance	Maintenance fees are required to be paid after one year.
ways of resolution	Phone, email, and remote assistance for diagnosis; if the issue cannot be resolved remotely, a solution will be negotiated.
Replace components	No service fee will be charged for replacements made during the warranty period; for modular replacements, customers may perform the replacement themselves.
shipping charge	If the item needs to be returned for replacement, the customer shall bear the shipping costs.
scope of application	Applicable only to the Chinese mainland region

Exclusions from after-sales coverage (exclusion clauses): -Intentional impact or fire damage-Unauthorized modification, disassembly, or removal of the casing-Incorrect installation, use, or operation-Damage caused by self-service repairs-Forcible operation when components are aged or damaged-Compatibility issues arising from simultaneous use with non-HEISHA-certified third-party components-Damage caused by insufficient battery power or battery usage quality issues-Product failure during uninterrupted operation or failure to operate without errors (not guaranteed) -Data loss or data corruption-Any software program-Malfunctions caused by third-party products-Technical support for "operating procedures" and configuration installation issues

9.8.2 HEISHA VIP After-Sales Policy Terms

VIP services add the following to the general policy:

clause	content
term of service	One-year VIP service; upon expiration, it will automatically switch to the standard policy.
extension of validity	Renewal is available
Free accessories	Accessories included with the VIP package are entitled to one free replacement.
Additional replacement	Any further replacement within one year will be charged at the standard market price; however, replacements may be performed free of charge within the number of free on-site support sessions provided.

The VIP after-sales price list is presented in the source materials in tiered categories by region (within Guangdong Province and in regions such as Fujian, Guangxi, and Zhejiang, followed by price tiers of 3,000/7,200/17,280/41,472 yuan); however, the correspondence between regions and price tiers is not aligned item by item in the original table. Official quotations shall be based on the latest VIP price list; this article does not

reproduce the table verbatim.

9.8.3 Comparison of the Two Policy Frameworks

Comparison item	General Policy	VIPpolicy
response time	24 hours	24 hours
defects liability period	1 year	1 year
On-site training	✗	☑1 time
in situ overhaul	✗	☑1 time
On-site maintenance	✗	☑1 time
Free tripod replacement	✗	☑1 time (partial gears)
Free battery replacement	✗	☑1 time (partial gears)
Free replacement of the control module	✗	☑1 time (partial gears)
cost	Free (during the warranty period)	Charging by region and fare class

9.8.4 Remote operations and maintenance capabilities

Q100 V2.0: Hangar Remote Operations and Maintenance Platform

DNEST: Equipment operation and maintenance, anomaly alerts, and remote maintenance functions

PDA: Supports remote image/firmware updates, incremental updates, and in-flight updates.

9.8.5 On-site commissioning tools

PDA Debugging Tool (Medical-Grade Standard)

Touchscreen control for PDA (458 control)

T3 Tool Kit

9.8.6 Empirical Evidence on Maintainability Design

Design Features	source	explain
Independent external service hatch	D90	Electrical modules can be serviced without opening the main cabin.
Centralized layout of electrical modules	D90	Reduce on-site fault diagnosis time
Facilitates the replacement of fire extinguishing cartridges	Patent CN222202949U	Fire extinguishing cartridges are consumables and must be replaced periodically.
Emergency Manual Unlock for Faults	D65	The doors may be opened manually in the event of an electric door failure.
Pull-out battery compartment	D90	Easy to access, place, and replace batteries

Service-level indicators such as response time (arrival time, repair time), spare-parts supply cycles, and the distribution of service outlets were not available for this study; they are listed in Appendix E. When requesting quotations, the supplier should be asked to provide a written confirmation of the above SLA.

9.9 Delivery Risks and Mitigation Recommendations

9.9.1 Exposing the genuine engineering challenges

The "Technical Challenges Solved" list documents approximately 70 real-world engineering problems. These problems are highly valuable — they demonstrate that HEISHA has been tempered by a large number of real-world projects, and their descriptions are extremely specific (for example: "When charging DCAP V3 M4E, the device cannot release the centering mechanism; if the remote controller charges simultaneously with the M4E drone, the airfield will go offline").

The problem description in the records above is reproduced verbatim; the original entry does not include a proposed solution. This document summarizes common remediation approaches based on engineering logic (see 9.9.2) and does not provide a final solution for HEISHA.

9.9.2 Summary of High-Risk Areas

Based on approximately 70 technical issues, the following high-risk areas have been identified:

Power Supply and Power Matching

question	risk
Unstable ACK150 voltage prevents charging	The charging module is sensitive to the input voltage.
D135: Insufficient external power supply	On-site power supply capacity is insufficient
Insufficient 12 V power supply within the T3	Insufficient internal power margin
D250 trips upon energization	Surge or short-circuit protection triggered
D135 AC busbar burnout	The connector's rated current is insufficient, or there is poor contact.
485 offline due to low supply voltage	The communication module is sensitive to voltage fluctuations.
Insufficient and unstable deployment environment power	Poor power supply quality in the field
The power supply board has insufficient power.	Insufficient distribution board capacity
Abnormal power supply to the Raspberry Pi when powered by 5 V	Unstable low-voltage power supply

Recommendation: During the requirements phase, the on-site power supply conditions (voltage range, capacity, and stability) must be clearly defined; a power budget should be calculated, and a margin of at least 20% should be reserved.

heat management

question	risk
Excessive power consumption in high-current switches / LDO overheating	Low power conversion efficiency
Excessively high ACK temperature prevents normal operation.	Insufficient heat dissipation in the charging module
D250 Raspberry Pi overheating	Insufficient heat dissipation design in the computing module
The D250 air conditioner has low airflow.	Improper duct design or fan selection

Recommendation: Thermal simulation should be completed during the design phase; critical heat-generating components should be equipped with temperature monitoring and overheat protection.

Return centering and transmission accuracy

question	risk
The coaxiality of the DCAP centering screw is deviated.	Processing accuracy or assembly error
DCAP V3 Centering, Lifting, and Trailing	Insufficient guide rail design or insufficient limiting
Return to the central pole	Mechanical interference
Release upon return cannot be stopped	Limit switch or control logic issue
D250 pusher motor step loss	Insufficient motor torque or drive-related issues
D135 centering motor fails to move	Load exceeds motor capacity
The slight tilt of the D135 centering push rod causes poor contact.	assembly precision
D135: Centering contact issue	Electrode alignment deviation
Neither the drum nor the centering can be controlled.	Control signal or drive fault

Recommendation: Alignment institutions should conduct thorough on-site verification before dispatching the equipment; after on-site installation, alignment accuracy calibration must be performed.

Charging compatibility

question	risk
The M4E cannot shut down and charge properly.	Flight control protocol compatibility issues
The M400 switchable version is unstable, resulting in the inability to charge.	Switching board hardware reliability
ACK800 Easy-Burn	Insufficient overcurrent protection
ACK2000 charging has no output	Charging module failure
D135 displays a battery certification failure message during startup charging.	Battery BMS communication issues
M4E: Frequent power cycling during charging / occasional failure to start	Charging protocol timing issues
D250 charging electrode contact issue	Electrode misalignment or insufficient

question	risk
	elasticity

Recommendation: For new models, complete charging cycle validation must be performed before shipment, including multiple power-on and power-off charging tests.

Multi-device concurrency

question	risk
The entire system shuts down when the DCAP remote controller and the drone are charged simultaneously.	Total power exceeds the limit or power supply conflict
When charging the DCAP V3 M4E, the device cannot be released while centering; additionally, the charging station goes offline during simultaneous charging.	Resource contention or communication conflicts

Recommendation: For scenarios involving simultaneous charging across multiple devices, stress testing must be conducted prior to factory release to define the power ceiling and timing constraints for concurrent charging.

Sensor reliability

question	risk
Rainfall counter does not reset to zero	Sensor reset logic issue
Temperature and humidity damage caused the 485 connection to go offline.	Sensor failure affects bus communication
Network RTK does not connect automatically.	RTK module initialization issue
Base station RTK cannot remain in standby mode for extended periods.	Base station power consumption or sleep strategy
The DJI remote cannot remain in standby mode for an extended period / cannot determine whether it is powered on	Remote control protocol restrictions
Wind speedometer transportation damage	Insufficient vibration resistance of the sensor

Mitigation recommendation: Critical sensors should incorporate redundancy or degradation strategies; the failure of a sensor on the bus should not affect communication with other devices.

Materials and Sealing

question	risk
Material rusting issue	Insufficient corrosion resistance rating
D250 leakage	sealing failure
When the drum is running, scrape the inner side of the upper cover's support leg.	motion interference
The DCAP V3 version base cover is relatively soft and prone to deformation.	Insufficient structural stiffness
D135 cover is tilted	assembly precision

Software Stability

question	risk
HSC Cloud Access app crashes	Memory leak or inadequate exception handling

question	risk
The DJI PILOT cannot start normally.	APP compatibility issues
The DJI RC Plus remote control may fail to power on randomly.	Remote control firmware or hardware issues
D135 motor alarm: false alarm indicating cover open status	State machine logic error
The Guangkan D250 router is unstable.	Network Equipment Reliability

9.9.3 Comprehensive Risk Mitigation Recommendations

1. During the requirements stage, the power budget and power supply conditions must be clearly defined: compile a list of the peak and continuous power requirements for all electrical equipment, and include a 20% margin as the basis for the power supply design.

2. Scenarios involving concurrent charging across multiple devices must be validated in advance: full-load concurrent testing should be conducted during the prototype stage.

3. Sensor redundancy design: Critical sensors (e.g., temperature and humidity sensors) should have backup units; the failure of a single sensor should not cause the entire bus to become inoperable.

4. Sealing and corrosion protection ratings should be selected based on the actual environment rather than the nominal rating; account for the microenvironment at the installation location (e.g., windward surfaces, water accumulation areas).

5. **Reserved joint integration period for software integration: The joint integration period between HSC/DNEST and the customer platform shall be determined based on the number of interfaces and the scope of customization; a dedicated joint integration phase should be included in the project schedule, and debugging shall not be used as a substitute for acceptance testing.**

6. On-site accuracy calibration after centering: After installation, the centering mechanism must undergo accuracy verification and adjustment.

7. Transportation protection: Precision sensors (such as anemometers) require specialized shockproof packaging during transport.

9.10 Requirements Input Checklist Template (Appendix Format)

Below is a blank RFI template that can be copied and used directly:

HEISHA Machine Warehouse Customization Requirements Input List (RFI)

Project Name: _____

Date entered: _____

Person completing the form/Contact information: _____

Target UAV model: _____

1. Basic Specifications

Requirements	fill in
Closed dimensions (length × width × height, mm)	
Unfolded dimensions (length × width × height, mm)	
Maximum weight (kg)	
Material preferences	□ Aluminum alloy □ Carbon fiber □ Stainless steel □ Glass fiber □ Galvanized steel sheet □ ABS+PVC □ Teflon □ Others___

2. Structural Transmission and Deployment Design

Requirements	fill in
Opening method	□ Flip cover □ Lift cover □ Side-opening □ Others___
Return-to-center method	□ Gravity □ Push rod □ Turntable □ Others___
T3 coalescence/separation	□Merged □Separated
In-vehicle requirements	□ None □ Shockproof □ Dynamic posture compensation
Deployment method	□ Forklift □ Crane □ Wheels □ Aluminum alloy base □ Concrete fixation □ Cabin integration
peripheral interface	□Emergency stop □Other ___

3. environmental suitability

Requirements	fill in
Minimum operating temperature	___℃
maximum working temperature	___℃
Salt spray rating	□None □C3 □C4-M □C5-M
IPgrade	□IP54 □IP55 □IP64 □IP65
Air conditioning mode	□Compressor □Semiconductor □Fan □PTC □Combination
Air conditioner power	___W
Heating method	□PTC □Heat pump □Electric heating
lightning-protection	□ Not required □ Lightning rod □ Surge protector

4. Intelligent components

Requirements	fill in
Surveillance camera	Quantity: ___ Location: □ Inside the warehouse □ Outside the warehouse
Weather sensor	□ Six essential elements □ Minimalist configuration □ Not required
Acoustic and visual alarm	□ Required □ Not required
RGBstatus lamp	□ Required □ Not required
fire-fighting equipment	□ Fire extinguisher □ Others ___ □ Not required

5. Power Supply Management

Requirements	fill in
input voltage	□AC110V □AC220V □DC24V □DC48V
UPS	□ Not required □ Rear ___Wh □ Front (□ Voltage regulation □ Power regulation □ Boost)
solar energy	□Not required □___W
Power status/fault reporting	□ Required □ Not required

6. Charging Management

Requirements	fill in
Charging power/current	_W / _A
security guard	□ OVP □ Undervoltage □ OCP □ Anti-backflow protection □ Anti-over-discharge protection □ Temperature monitoring
Power On/Off Function	□ Required □ Not required
Switching board	□ Not required □ Required (Model: ___)

7. communication

Requirements	fill in
Primary Communication	□4G □5G □RJ45 □STARLINK □Private Network
Redundant communication	□Not required □___
Signal strength reporting	□ Required □ Not required

8. UAV-assisted

Requirements	fill in
Charging stand	□ Standard □ Customized (Model ___)
Remote control base	□ Not required □ Single workstation □ Dual workstation
base stationRTK	□ Not required □ Built-in □ External

9. Interfaces and Documentation

Requirements	fill in
Interface Protocol	□MQTT □MODBUS RTU □MODBUS TCP
Video streaming	□RTMP □RTSP □Not required
Status Reporting	□ Full Perception □ On-Demand Tailoring
HSCsource code	□ Purchase □ Not required
DNESTsource code	□ Purchase □ Not required □ Self-built

10. supplementary information

Requirements	fill in
Project Volume and Delivery Pace	
Installation site requirements	
Local regulatory requirements	
acceptance level	
Operations and Maintenance Strategy	□ Self-operated and maintained □ HEISHA operation and maintenance □ Hybrid
life expectancy	___year
Other Special Requirements	

Charpter 10 Application Forms and Case Studies

10.1 Case Description and Data Boundary Declaration

This chapter presents the application format for information statements that can be verified against product documentation. Any sections involving the customer's name, deployment location, delivery date, and actual operational data must be disclosed only after obtaining the customer's written authorization; content without such authorization shall be presented as a format example, with the required supplementary information provided using Template 10.10.

This statement is not intended to disparage others; rather, it is an expression of honesty. For technically oriented readers (integrators/engineers), genuine product capabilities and technical specifications provide greater reference value than packaged "success stories." Each product form itself serves as proof of the system's modular integration capabilities.

Value of this chapter: -Demonstrates the modular system's combinability and the

breadth of its scenario coverage through more than 12 product forms; -Provides the technical parameters and design considerations for each form as a reference baseline for selecting a new project; -Highlights real-world engineering challenges (see Section 9.9), serving as a guide to avoid common pitfalls in subsequent projects.

Recommended checklist of additional case elements

essential factor	explain	priority
Customer Industry and Use Cases	such as "power grid inspection," "mining area monitoring," and "border security and control"	High
Deployment Location and Environmental Conditions	Such as "Xinjiang Gobi", "Northeast Coast", and "Plateau at 3,000m".	High
Delivery Time and Quantity	For example, "deliver 5 units in Q3 2025"	High
Module Configuration Sheet	MD/JD/ND code + environmental package + optional components	High
Actual operating performance metrics	e.g., "continuous fault-free operation for 180 days" and "measured temperature control accuracy of ±2 °C"	High
photo of the scene	Real-world photos after installation (not rendered images)	Midum
Customer Authorization Status	Whether customer consent has been obtained for the public disclosure of case information	High
Operations and Maintenance Record Summary	Number of failures, average repair time, and spare parts consumption	Midum

---

10.2 Product Form Panorama

10.2.1 Product Family Tree

graph LR

subgraph Ground Fixed Series

D65[D65]

D80[D80]

D100[D100]

D135[D135]

D200[D200]

D250[D250]

end

subgraph: For extreme environments

D90 [D90 Extreme Cold & Extreme Dust]

```
end

subgraph In-Vehicle Series
DCAP[DCAP]
DCAP_PRO[DCAP PRO]
DCAP_MINI[DCAP MINI]
DCAP_LITE[DCAP LITE]
CAR_INBUILT [In-car embedded storage]
ZIGLER [ZIGLER Solution]
CAR_MOD [Vehicle Modification]
end

subgraph Portable Series
D007 [D007 Suitcase-style]
end

subgraph Suspension/Logistics Series
D330 [D330 Stowed Hangar]
V200 [V200 Container Lift]
end

subgraph Indoor Series
OWL [Owl Indoor Unit Warehouse]
INDOOR [Indoor Warehouse Inspection]
end

subgraph Special Series
TETHER [Custom Tethered Hangar]
DPAD [DPAD Centered Charging Board]
```

end

Figure 10-1 HEISHA Product Lineup Diagram

10.2.2 Key Parameters: Comparative Summary Table

model	Closing dimension (mm)	Open Dimensions (mm)	weight(kg)	IP grade	working temperature(℃)	Compatible devices	supply electricity	power dissipation
D65	/	/	/	IP55	/	/	/	/
D80	/	/	/	IP54	/	/	/	/
D90	1550 × 1550 × 1740	/	500	IP65	-40~+65	Industrial Multirotor/ VTOL	AC220V ± 20%	/
D135	/	/	/	IP54	/	/	/	/
D200	/	/	/	IP54	/	/	/	/
D330	2592 × 2066 × 1278	/	650	IP54	-20~+55	Yuandu Lingsun ZT-25V	AC210-240V	≤2500W
V200	Container (internal dimensions: 5690 × 2130 × 2180)	—	2000	IP54	-20~+55	Folded fixed-wing / Ark 20	AC220-240V	≤4500W
D007	950×570×440	/	45	IP54	-5~+55	DJI M3E	DC24V	≤ 150 W/≤350 W peak
DCAP MINI	1360 × 750 × 280	1360 × 1480 ×280	67	IP54	0~+55	2S-4S compatibility	DC24V	≤150 W/≤ 350 W peak
Tethered hangar	1200 × 1000 × 1500	1800 × 1000 ×1500	85	IP54	-20~+50	Kodiwei 3F, etc.	AC100-240V	≤800W

Parameters marked "—" in the table represent items for which data are not provided; these have been summarized in Appendix E. When conducting a side-by-side comparison, note that the power definitions differ among products (sub-item power versus total machine input); the values should be taken as specified on the product page.

10.3 Case 1: All-weather operation in extreme cold and extreme dust conditions (D90)

Scene Background

The D90 is the product with the most comprehensive existing documentation among those developed by HEISHA; it is a heavy-duty, protective UAV autonomous operation base station designed for extreme field environments worldwide. Its application scenarios include polar scientific research, coastal security, mining zone monitoring, desert pipeline inspection, and border security and control.

Environmental constraints

restrain	Specific Requirements
Ultimate Dust	The Gobi Desert and open-pit mining areas are subject to persistent wind-blown sandstorms; the resulting dust infiltrates the cabin, causing wear to the drone's power system, gimbal, and charging interface.
extreme of cold	Low temperatures reduce the activity of lithium-ion batteries, making it highly likely that frost or condensation will form inside the compartment, thereby causing circuit failures.
High salt spray	Coastal sea-salt fog continuously corrodes sheet metal, hinges, and electrical connectors.
Remote deployment	It is difficult for personnel stationed at scientific research sites, deserts, and remote coastal tidal flats to remain on-site permanently; therefore, the frequency of on-site operations and maintenance should be minimized as much as possible.
snow cover	Traditional flat-roof structures are prone to the accumulation of snow and sand.

Technical Challenges and Solution Architecture

throw down the gauntlet	D90 Solution	Empirical parameters
Ultrafine Dust Protection	Fully sealed structure + Teflon material opening components	IP65, fully enclosed multi-stage dust protection
Extreme Cold Activation	Three-stage temperature control strategy (preheating → heat retention → constant temperature)	-40℃~+65℃,±3℃ accuracy
Anti-frosting	Dual closed-loop coordinated control of temperature and humidity	Constant cabin temperature: 5°C–25°C
antiseptic	C4-M: High corrosion resistance + stainless steel fasteners	Suitable for deployment along coastal areas and on islands
snow cover	Four-slope sloped-roof flow diversion design	Snow load ≥ 120 kg/㎡
supply electricity	Integrated solar power + optional off-grid photovoltaic energy storage	Install solar panels on the top and sides
communication	Bidirectional command validation + breakpoint resume + offline caching + automatic data retransmission upon reconnection	Support for optional satellite communication modules
operation	Independent external maintenance hatch + centralized layout of electrical modules	Reduce on-site fault diagnosis time

Summary of Key Indicators

project	parameter
External overall dimensions (closed)	1550mm×1550mm×1740mm

project	parameter
Pad dimensions	800×800mm
Total unit weight	500kg
levels of protection	IP65
operating temperature range	-40℃~+65℃
Cabin constant-temperature operating range	5℃~25℃
Temperature control accuracy	±3℃
Salt spray corrosion resistance rating	C4-M
Snow load capacity	≥120kg/㎡
Operating humidity range	5% RH–95% RH, no condensation
material quality	Aluminum alloys, stainless steel, PTFE, etc.
input voltage	AC220V ±20% 50Hz

Optional add-ons

D90 Optional Expansion Configuration List: -Off-grid photovoltaic energy storage power supply system-Satellite communication terminal module-Structural reinforcement and upgrade kit for severe wind and snow conditions-UAV automatic battery swap module-Local edge computing server-Lightning protection system upgrade-Intelligent heating module-Intelligent cooling module

Deployment method

The D90 supports three deployment configurations: -Fixed installation: permanently mounted on a concrete base-Integrated installation: deployed on mobile shelters or vehicle-mounted platforms-Temporary deployment: rapid hoisting and deployment at field tidal flats or scientific research sites

The power supply supports municipal AC power; a photovoltaic energy storage system can be optionally installed to enable off-grid independent operation. The base provides multiple standard lifting rings and fixed mounting points; the integrated load-bearing base supports ground fixation, integration into modular shelters, and rapid deployment at temporary sites.

System topology and service links

The operational execution chain for D90 is as follows:

Task issued via cloud platform (provided by the customer) → Hangar door opened → UAV takes off for aerial photography/inspection →

Upon task completion, automatically return and align → automatically charge → close the hatch

Drones collect data, and equipment operating status is transmitted in real time to the cloud-based scheduling platform. Heisha makes all hardware interfaces available, enabling customers to develop their own cloud-based scheduling platforms. The communication module is provided by the customer, while Heisha is responsible for its integration.

This architecture reflects HEISHA's positioning as a provider that focuses solely on the hangar platform: the cloud-based scheduling platform is either provided by the customer or purchased through DNEST, while HEISHA supplies a standardized interface from the hangar to the cloud (MQTT/MODBUS RTU/MODBUS TCP). This decoupled design enables D90 to flexibly integrate with the business systems of different customers.

illustrating picture

D90 Extreme Cold & Extreme Dust Hangar Exterior

Figure 10-2 D90 Ultra-Cold and Ultra-Dust All-Weather Unmanned Aircraft Automatic Hangar

D90 System Topology Architecture

Figure 10-3 D90 System Topology Architecture Diagram

D90 Product Specifications

Figure 10-4 D90 Product Parameter Information (I)

D90 Field Deployment

Figure 10-5: Actual on-site deployment of D90

10.4 Case 2: In-Vehicle Mobile Deployment (DCAP MINI / In-Vehicle Embedded ZIGLER)

10.4.1 DCAP MINI: Third-Generation Roof-mounted Nest

The DCAP MINI is the third-generation industry-grade rooftop drone nest from HEISHA; its key features include:

project	parameter
Closed dimensions	1360 mm × 750 mm × 280 mm (excluding the mounting base)

project	parameter
Open dimensions	1360mm×1480mm×280mm
weight	67kg
levels of protection	IP54
material quality	All-metal sheet metal fabrication
supply electricity	DC24V
Standard operating condition power consumption	≤150W
Peak power consumption	≤350W
Maximum charging current	6A
operating ambient temperature	0°C to 55°C (heating module optional)
Mission Interval	35mins
recovery mode	Autonomous precision landing (drone RTK)
working life	≥5,000 hours
protect	Anti-backflow

Key considerations for automotive-grade design: -Adopt automotive-grade primary control performance requirements-Use automotive connectors and wiring harnesses-Provide automotive-grade vibration isolation and stability-Incorporate a comprehensive onboard operating system that supports both local control and remote diagnostics and maintenance

DCAP MINI Roof-mounted Device Nest

Figure 10-6 DCAP MINI: Third-Generation Industry-Class UAV Roof-mounted Nest

DCAP MINI Details

Figure 10-7: DCAP MINI Architecture and Interface Details

10.4.2 In-vehicle embedded storage unit

Key features of the vehicle-mounted embedded control unit: -Modular design, compatible with chassis from a wide range of vehicle models-Built-in shock-absorbing mechanism and electromagnetic shielding layer-Integrated dual-mode GPS/Beidou positioning and 4G/5G communication modules-Power supply system compatible with vehicle cigarette lighters and chassis power sources-Overvoltage, overcurrent, and reverse-polarity protection

In-vehicle embedded storage unit

Figure 10-8: Installation effect of the in-vehicle embedded control cabinet

Interior of the vehicle-mounted embedded storage unit

Figure 10-9 Internal structure of the in-vehicle embedded machine room

10.4.3 ZIGLER Solution

Key features of the ZIGLER in-vehicle embedded solution: -Deeply integrated into specialized operational vehicles-Seismic reinforcement structure and dynamic attitude compensation capability-Compatibility with takeoff and landing during high-speed movement-Built-in edge computing unit capable of processing aerial photography data in real time and synchronously transmitting it back to the command center-Open interface protocols, compatible with mainstream drone brands and mission payloads-Applicable to multiple scenarios, including emergency communications, patrol, inspection, and mapping

ZIGLER in-vehicle solution

Figure 10-10 ZIGLER In-Car Embedded Solution

ZIGLER Integrated Details

Figure 10-11: Details of ZIGLER solution integration

10.4.4 Special Technical Challenges in In-Vehicle Scenarios

Compared with ground-based fixed deployment, in-vehicle deployment faces four additional challenges:

throw down the gauntlet	influence	Response measures (empirically verifiable)
vibrate	Mechanical loosening, weld point fatigue, sensor drift	Automotive-grade main control unit, automotive terminal wiring harness, shock-absorbing mechanism
Postural change	Decreased charging accuracy and poor charging contact	Dynamic Attitude Compensation (ZIGLER)
supply variation	Voltage surge when the vehicle starts or shuts off	Overvoltage/overcurrent/reverse-polarity protection and DC24V voltage regulation
electromagnetic environment	Vehicle electronic equipment interference	Electromagnetic shielding layer

---

10.5 Case 3: Vertical Take-off Drones and Logistics Transfer (D330 / V200)

10.5.1 D330 Stowed Hangar (Yuan Du)

D330 is specifically designed for vertical takeoff and landing fixed-wing drones; eight-section abstract:

Core positioning: Integrates autonomous storage, head-direction adjustment,

charging, status monitoring, and remote dispatching functions; supports expansion and compatibility with multiple models of the same size.

Basic Specifications:

project	parameter
Cover dimensions	2592×2066×1278 mm (without wings; wings are detachable; without foot cups)
net weight	650kg(bias ≤±3%)
Rated maximum power	2500 W (peak ≤ 2500 W, continuous ≤ 10 min)
levels of protection	IP54
input voltage	AC 210V~240V，50/60Hz，±10%
working temperature	-20 ℃ to +55 ℃ (performance degradation ≤ 5%)
Primary material	Aluminum alloy profiles + glass-fiber composite materials + stainless steel components
way to install	Expansion bolt fixation (M12×100)
Pad dimensions	1.4m×1.4m
Compatible devices	Yuan Du Ling Sun ZT-25V

Temperature control system: − Compressor air conditioner: 220 V/110 V, 280 W, cooling capacity 550−800 W, 4 settings, 16−32 °C − PTC heater (optional): 220 V, steady-state power 400 W, peak power 1,000 W

Power consumption: -Standby: ≤80 W-Operating (including charging): ≤2,500 W-UPS (optional): 4,500 Wh

Control system: -Main controller board: T100-Operating system: Embedded Linux-Human-machine interface: 4.3-inch touch screen

D330 Stowed Hangar

Figure 10-12 D330 Automated UAV Hangar System

D330 Dimensional Drawing

Figure 10-13: Schematic diagram of the D330 cover opening dimensions

10.5.2 V200 Container Lift Hangar

The V200 features a containerized design; its core specifications are as follows:

project	parameter
inside dimension	569cm×213cm×218cm（L×W×H）
weight of equipment	2T

project	parameter
Rated maximum power	4500W（MAX）
levels of protection	IP54
input voltage	AC 220V~240V，50/60Hz
working temperature	-20℃~+55℃
Primary material	High-strength material specifically designed for containers
Standby power consumption	≤80W
Operating power consumption	≤4500W
UPS (optional)	4500Wh
Charging time	120 minutes (full charge)
Charging Protection	Instead, overfilling, overpressure, and overcurrent

Customizable expansion: Supports the installation of solar panels.

V200 Container Lift Hangar

Figure 10-14 V200 Containerized Vertical Takeoff UAV Hangar

10.5.3 Special technical requirements for the deployment of fixed-wing aircraft

Compared with multi-rotor UAVs, fixed-wing UAVs have the following specific requirements for the hangar:

requirement	APIsupport	explain
Wing span	—	D330 wings feature a detachable design
Airflow through the anemometer tube	pitot_tube_open / pitot_tube_close	Specialized command for lowering
Return transfer disk	rotate_motor_stop / rotate_motor_position	Nozzle direction calibration
Paddling	pulp_motor	Paddle collection motor status ("paddle collection" and "paddle recovery" used interchangeably)

10.5.4 API support for logistics scenarios

The API physical model contains logistics-related attributes and commands:

Attribute/Command	type	explain
locker_door_state	Array (32 elements)	Multi-port gate status
locker_state	Array (32 elements)	Multi-slot state
machine_arm	struct	Three-axis robotic arm
start_loading	method	Start loading
start_unloading	method	Start unloading
start_pickup	method	Start picking up the item
start_dropdown	method	Start submitting

Attribute/Command	type	explain
start_storageing	method	Start storing

Please note the distinction: D330/V200 belongs to the D series (developed independently by Heisha), whereas the logistics cabinet T series (T20/T400/T60 Pengchao Warehouse) represents a different configuration. The aforementioned logistics API primarily targets the T series; whether D330/V200 provides support depends on the software version actually configured.

10.6 Case 4: Portability and Indoor Scenarios (D007 / Owl / Indoor Warehouse Inspection)

10.6.1 D007 Stowed Aircraft Hangar

D007 is a portable hangar independently developed by Heisha; its key features are:

project	parameter
Close size	95×57×44 cm (150-inch suitcase)
weight	45kg
levels of protection	IP54
material quality	Aluminum alloy frames and frames; ABS and PVC enclosures
supply electricity	DC24V
Standard operating condition power consumption	≤150W
Peak power consumption	≤350W
Maximum charging current	6A
operating ambient temperature	-5 °C to 55 °C
Mission Interval	35mins
recovery mode	Autonomous precision landing (drone RTK)
working life	≥5,000 hours
internal battery	Provides up to 5 hours of standby time
Compatible charging	2S–4S automatic charging; the standard model is compatible with DJI M3E.
Return-to-center method	Gravity-based centering
Built-in main frame	detachable
function	Automatic lid opening, automatic charging, automatic power on/off
telemanagement	Can be used in conjunction with the basic edition of DNEST.

Engineering implications for portable scenarios:

The design of the D007 strikes a balance between portability and functionality: -A weight of 45 kg allows a single person to carry it; -The built-in battery provides 5 hours

of standby time, making it suitable for temporary deployments without external power; -Gravity-based centering reduces the weight and power consumption of the electric centering mechanism; -The ABS+PVC case has an appearance indistinguishable from that of a conventional suitcase, minimizing the need for special handling during transport and deployment; -The detachable main frame facilitates maintenance and replacement.

D007 Stowed Aircraft Hangar

Figure 10-15 D007 Stowed Drone Hangar

D007 Expanded State

Figure 10-16: D007 in unfolded operating condition

10.6.2 Owl Indoor Unit Warehouse

The available documentation for this configuration consists solely of product images; the specifications, compatible models, and functional features have not been provided with the documentation. This section describes the product based on the structural features discernible from the images; the parameters shall be subject to the specifications provided in the specification sheet (see Appendix E).

Owl Indoor Unit Warehouse

Figure 10-17 Owl Indoor Unit Warehouse (Exterior)

Interior of the owl indoor unit storage room

Figure 10-18 Owl Indoor Unit Warehouse (Internal Structure)

Details of the Owl Indoor Unit Storage Room

Figure 10-19 Owl Indoor Unit Cabinet (Detail)

The items subject to verification for this configuration include the product name, specifications and parameters, compatible device models, and application scenarios; these are listed in Appendix E. The differences from the outdoor unit cabinet primarily lie in the positioning method in the absence of satellite signals and the compact housing design (see 10.6.3).

10.6.3 Indoor Warehouse Inspection

Only video materials are provided; no textual description is included.

Compared with outdoor environments, indoor settings have the following distinctive characteristics: -No GPS/RTK: visual or QR-code-based positioning is required as a substitute-No wind or rain loads: however, there may be a risk of collisions (due to racks,

forklifts, etc.) -Convenient power supply: typically has a stable utility power supply-Limited space: ceiling height and rack spacing constrain the dimensions of the hangar and the method of opening the cover-Good network conditions: typically has WiFi or Ethernet coverage-Stringent fire safety requirements: indoor space generally has higher fire safety standards than outdoor spaces

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10.7 Case Study 5: Specialized and Cross-Domain Applications

10.7.1 Customized mooring hangar

Basic specifications for a mooring hangar:

project	parameter
weight	85kg
Open dimensions	1800×1000×1500mm
Closed dimensions	1200×1000×1500mm
maximum power	800W
levels of protection	IP54
input voltage	AC100~240V
working temperature	-20℃~+50℃
Compatible devices	Kodiway 3F / Other same sizes
battery capacity	6S

API support: -Tethering component properties: tethering (struct): state (0 = off / 1 = on), level (0 = stopped / 1 = gear 1 / 2 = gear 2); -Tethering commands: tethering_open / tethering_close / tethering_level_set; -Drum commands: activate tethering high-voltage / deactivate tethering high-voltage / reel in at gear 1 / reel in at gear 2 / stop reeling; -The compatible model list includes the Flaredynamic TETHER DRONE.

10.7.2 Custom DPAD Centering Charging Board

This product is currently presented in the form of video material; its specifications and application scenarios are not provided with the material. This section describes the product based on its functional positioning as a centering charging board; the parameters are provided in Appendix E.

10.7.3 Vehicle modification

This section is currently presented in the form of video materials; the modification solutions and applicable vehicle models are not provided with the materials. This section

describes the general engineering constraints for in-vehicle modifications; specific solutions are developed on a project-by-project basis (see Appendix E).

10.7.4 Cross-domain Application: Building Houses for Robots

FAQ: A clear answer to "Can 'HEISHA' provide custom hangars for robotic dogs?"

"Certainly. HEISHA specializes in building housing for robots; we can provide customized wired and wireless charging facilities for robotic dogs, as well as customized hangars for unmanned tractors and unmanned aircraft boats."

This demonstrates that the product positioning of HEISHA is not limited to drones; it is also oriented toward a broader range of robotic platforms. The core capabilities of the hangar — protection, temperature control, charging, communication, and control — are applicable across different types of robots.

10.7.5 Maritime/Shipboard Application Leads

The existing evidence from the classification society is the container certificate issued by the Midum Classification Society (Midum CLASSIFICATION SOCIETY) (certificate number GTD24S4332, with the certifying manufacturer being Guangdong Xinhui CIMC Special Transport Equipment Co., Ltd.), the details of which are provided in Section 8.5.3. The certificate certifies the container hull rather than the entire shipyard unit; the classification society's acceptance status for the entire shipyard unit is listed in Appendix E.

Class society certification pertains to maritime and onboard application scenarios; the certification body, scope of application, and certification level vary depending on the project application. This article does not provide specific acceptance information (see Appendix E).

Classification society certification (such as CCS, DNV, ABS, etc.) is a mandatory entry requirement for ships and marine engineering equipment. If HEISHA has indeed obtained classification society certification, this means that its products may be used for: -UAV takeoff and landing platforms on ship decks-Base stations for UAVs used in offshore wind power operation and maintenance-UAV operation systems on marine research vessels-Shore-based or ship-based hangars for UAVs conducting port/ navigation channel inspections

This is a high-value niche market; it is recommended that detailed information regarding classification society certification be provided (organization, certificate number, scope of application, and validity period).

10.7.6 Energy storage cabinet integration

The version history indicates that "on 2025.10.10, the functionality and parameters of the HEISHA energy storage cabinet were updated"; the product specifications state that the energy storage cabinet has an IP64 protection rating. Relevant images of the ACK2000 charging module (image58~62.png) also appear in the product introduction.

As a core component of off-grid photovoltaic power supply solutions, the energy storage cabinet complements extreme-environment equipment shelters such as the D90. An IP64 protection rating provides dust protection level 6 (fully dustproof) and water protection level 4 (splash-proof), making it suitable for outdoor deployment; however, this differs from the IP65 rating of the D90. When selecting an off-grid power supply solution, system integrators should ensure that the protection rating of the energy storage cabinet matches that of the equipment shelter.

10.8 Scenario — Configuration Comparison Table

application scenarios	Environmental Characteristics	Recommended product format	Key Configuration Considerations	Verified models
Polar Scientific Research	-40 °C, strong winds, accumulated snow	D90	PTC heating + three-stage temperature control + C4-M corrosion protection + photovoltaic energy storage + satellite communications	D90
Coastal Security	High salt spray, humidity, typhoons	D90	C4-M corrosion protection + IP65 + lightning protection + wind-resistant structural reinforcement	D90
Mining Area Monitoring	Dust, vibration, high temperature	D90/D135	IP65+fully sealed + PTFE + forced heat dissipation	D90 / D135
Desert Pipeline Inspection	High temperatures, sandstorms, and no grid power	D90	Off-grid photovoltaic energy storage + IP65 + satellite communication	D90
Border Control and Prevention	Low temperatures, remote locations, and extended on-duty periods	D90	Extreme Cold Packaging + Satellite Communications + Edge Computing	D90
traffic patrolling	Vehicle-based, mobile, and rapid response	DCAP MINI/ZIGLER	Automotive-grade main controller + DC24V + shockproof + 4G/5G	DCAP MINI / In-vehicle embedded
Emergency Rescue	Vehicle-mounted, temporary deployment,	D007/DCAP	Portable + Built-in Battery + Rapid	D007 / DCAP

application scenarios	Environmental Characteristics	Recommended product format	Key Configuration Considerations	Verified models
	multi-scenario	MINI	Deployment	MINI
Long-duration surveying and mapping	Lower the fixed-wing configuration and achieve broad-area coverage	D330/V200	Turntable centering + anemometer + pitch adjustment + RTK base station	Yuandu Lingsun ZT-25V / Ark 20
logistics	Multiple berths, cargo loading and unloading, and dense route networks	T Series (D330/V200)	Multi-compartment management + robotic arm + loading/unloading instructions	D330 / V200
Indoor Inspection	No GPS, limited space, collision risk	Owl/Indoor Warehouse Inspection	Visual/QR positioning + compact design	Owl/Indoor Model
Tethering monitoring	Continuous hovering; wired power supply	Tethered hangar	Tensioned wire take-up and release + high-voltage power supply + dual-range wire take-up	Kodiway 3F/Flaredynamic
Robotic dog / autonomous vehicle	Ground robots; non-aerial	Customized hangar	Wired/wireless charging + compatibility with robot dimensions	Customized (DPAD Series)

The "Recommended Configuration" column in the table is presented based on product parameters and the module coding system and serves as a selection recommendation; the "Verified Model" column is filled in according to the delivered configuration, while the specific project's model verification records shall be subject to the configuration sheet.

10.9 Proof of the depth of technical accumulation

10.9.1 Patent Composition Analysis

Heisha has filed a total of 36 patents, comprising the following:

class	Total	Patent Maintenance	Pending substantive review proposal	Withdrawn/Rejected/Invalidated
patent of invention	18	2	5	11
utility model	16	15	—	1
appearance design	2	1	—	1
amount to	**36**	**18**	**5**	**13**

Distribution of specific statuses for 11 expired invention patents: 3 patent applications withdrawn; 3 patents rejected and expired; 2 patents deemed withdrawn due to expiration after the deadline; 1 patent subject to a reexamination request resulting in rejection; 1 patent subject to a substantive examination request deemed withdrawn due to

expiration; and 1 patent whose rights terminated due to non-payment of annual fees (including cases of restoration).

Factual presentation: Among the 18 invention patents, 2 have had their patent rights maintained, 5 are awaiting substantive examination, and 11 have been withdrawn or have lapsed. This composition provides valuable insight for technical readers: on the one hand, it indicates that R&D investment remains active (with 5 invention applications still undergoing substantive examination in 2024−2025); on the other hand, it indicates that the historical grant rate for invention patents has been relatively low. By comparison, among the 16 utility model patents, 15 have remained valid, indicating that innovation output at the institutional and structural level has remained stable.

10.9.2 Inventive patents maintained under patent rights (2 items)

patent name	request number	Authorization Publication No.	Authorization Publication Date	Primary Classification Number
An intelligent drone charging station with rapid battery cooling functionality	202210205995X	CN114425958B	2024-04-12	B60L53/30
A UAV Propeller Recovery Mechanism System	2022100869473	CN114408157B	2023-12-22	B64C1/30

Note: Another invention patent, "A Portable Automatic Charging Platform for Drones" (application no. 2019109725146; granted publication no. CN110667426B; granted publication date: 2022-09-02), was previously granted. Its current status is "Patent rights have expired due to non-payment of annual fees; pending restoration," and therefore it is not included in "Patent rights maintained."

10.9.3 Utility models for which patent rights have been maintained (15 items)

patent name	request number	Authorization Publication No.	Authorization Publication Date
An airfield for UAV parking	2024207216862	CN222373139U	2025-01-21
A drone storage facility designed for easy replacement of fire extinguishing rounds and stable parking	2024206683345	CN222202949U	2024-12-20
A drone storage facility designed for easy transport and equipped with fire suppression munitions	2024206683260	CN222614939U	2025-03-14
A Portable UAV Battery	2024205852632	CN222062310U	2024-11-26

patent name	request number	Authorization Publication No.	Authorization Date	Publication
Management Box				
A small-scale UAV fleet suitable for vehicle-mounted deployment and equipped with solar panels	2024205036066	CN222040790U	2024-11-22	
A compact, vehicle-mounted drone library	2024205036051	CN221986641U	2024-11-12	
A drone storage facility with a roof or hatch that slides open to access the hangar	2024205036070	CN222040789U	2024-11-22	
A UAV blade collection device and a helipad	2024204632300	CN222663815U	2025-03-25	
An Intelligent Charging Landing Gear for Drones	2023207813500	CN219821785U	2023-10-13	
A charging platform with a large takeoff and landing area for drones	2020220822599	CN213973614U	2021-08-17	
A drone battery	2020219801252	CN214001365U	2021-08-20	
A charging landing gear for a drone	2020216247255	CN213974441U	2021-08-17	
A temperature control circuit for a motor speed regulator	2020207703850	CN212115200U	2020-12-08	
A drone landing gear with charging functionality	2019217145504	CN210681141U	2020-06-05	
An electrode arrangement structure for the centering mechanism of a UAV charging platform	2019217151276	CN210838982U	2020-06-23	

Another utility model, "A Drone Battery Connection Device" (application no. 2021206808559; granted publication no. CN214729715U; grant publication date: 2021-11-16), has lapsed due to failure to pay the annual fee and is therefore not counted among the valid patents.

The technical distribution across these 15 effective utility models is highly informative: five relate to charging landing gear and charging platforms (CN219821785U, CN213973614U, CN213974441U, CN210681141U, CN210838982U); two relate to onboard aircraft hangars (CN222040790U, CN221986641U); two relate to fire protection systems (CN222202949U, CN222614939U); two relate to door and retraction mechanisms (CN222040789U, CN222663815U); two relate to portable devices and battery management (CN222062310U, CN214001365U); one relates to overall aircraft configuration (CN222373139U); and one relates to motor temperature control circuits (CN212115200U). This distribution corresponds to the three-motion module architecture

described in Chapter 3 and the charging system described in Chapter 4, indicating that the patent portfolio is not composed of scattered applications but is instead organized around a core set of technical technologies.

10.9.4 Inventive patents pending substantive examination (5 items, representing ongoing research directions)

patent name	request number	Public ID	Application Date	Primary Classification Number	Pointing direction
Drone hangars, hangar control systems, and hangar control methods	2025104790318	CN120229407A	2025-04-16	B64U80/70	Control Systems and Control Methods
UAV remote charger	2025100597364	CN119637147A	2025-01-15	B64U50/37	Remote Charging Technology
A fully openable and closable drone storage system	2025100274387	CN119737081A	2025-01-08	E04H6/44	A New Form of Door-Motion Module
A drone hangar with drone centering functionality	2024118070337	CN119611847A	2024-12-10	B64U70/97	Mobile Centering Method
Drone logistics airport	2024117556935	CN119551243A	2024-12-03	B64U70/90	Overall form factor for logistics scenarios

Among them, "drone hangars, hangar control systems, and hangar control methods" was jointly applied for by Guangdong Xinhui CIMC Special Transport Equipment Co., Ltd., Midum International Marine Container (Group) Co., Ltd., and Shenzhen Heisha Technology Co., Ltd., while the remaining four items were independently applied for by Shenzhen Heisha Technology Co., Ltd.; the specific details of the cooperation fall outside the scope of this article.

These five pending patents were filed between December 2024 and April 2025; furthermore, their focus has shifted from the early stage of "single-institution innovation" to a combined approach encompassing "control methods + centralized allocation methods + fully open-loop structures + integrated logistics systems + remote charging." This indicates that R&D investment is evolving from a purely structural focus toward an equal emphasis on both structure and control methods, while also beginning to extend toward integrated system architectures for new application scenarios such as logistics.

10.9.5 Design (2 items)

patent name	request number	Authorization Publication No.	Authorization Publication Date	state
Drone charging station	2020307616542	CN306768576S	2021-08-20	Patent Maintenance

patent name	request number	Authorization Publication No.	Authorization Publication Date	state
Drone rain protection device	2020305278772	CN306768292S	2021-08-20	The patent right expires upon non-payment of the annual fee; restoration is pending.

10.9.6 Correspondence between granted invention patents and product capabilities

patent	Corresponding product/function	explain
An intelligent drone charging station with rapid battery cooling functionality (CN114425958B)	Charging system	Rapid battery cooling technology has been applied to the ACK series charging modules.
A UAV Propeller Receiving Mechanism System (CN114408157B)	Active ND19–ND21 + API pulp_motor	The paddle drive mechanism has been productized and exposed via the API.
A drone storage facility that facilitates the replacement of fire extinguishing rounds and provides stable parking (CN222202949U)	fire extinguisher system	The fireball design emphasizes ease of replacement.
A drone storage facility that is easy for transportation and equipped with fire extinguishing rounds (CN222614939U)	fire extinguisher system	Safety of Fireball Transport

10.9.7 The Value and Regrets of the "Technical Challenges Overcome" List

The "Technical Challenges to Be Solved" list documents approximately 70 real-world engineering problems across eight major categories: power supply, thermal management, centering and transmission, charging compatibility, concurrent operation of multiple devices, sensor reliability, material sealing, and software stability.

Value: This checklist itself serves as the most compelling testament to eight years of accumulated engineering experience. The problem descriptions are extremely specific—for example, "During DCAP V3 M4E charging, the centering mechanism cannot be released; when the remote control charges simultaneously with the M4E drone, the airport goes offline." Only someone who has actually worked on such projects can produce details of this level of specificity.

This list contains only problem descriptions and does not include proposed solutions. Its value lies in the specificity and breadth of the problems (approximately 70 items, covering nine engineering domains); experience gained from addressing these issues has been fed back into module iterations. Individual solutions have been compiled separately and are not discussed in detail in this article.

10.9.8 Product form diversity as indirect evidence of technical capability

The existence of more than 12 product forms themselves serves as the best testament to the system's modular assembly capability. Each form represents an engineering solution tailored to different sets of constraints:

Morphology	Core Constraints	Engineering Innovations
D90 Extreme Cold & Extreme Dust	-40℃ + IP65 + C4-M	Four-slope sloped roof + three-stage temperature control + PTFE sealing
DCAP MINI in-vehicle	Vibration + DC24V + Compact	Automotive-grade main controller + automotive terminal wiring harness + vibration-damping design
D007 Suitcase	45 kg + portable + built-in battery	Gravity-centering + ABS/PVC housing + detachable frame
D330 Downward tilt	Wing extension + nose attitude	Spin-off centering + free-flow tube air blowing + pitch mechanism
V200 container	Large dimensions + standardized transportation	Container configuration + maximization of internal space
Tethered hangar	Wired power supply + continuous hover	Tensioned wire take-up and release + dual-pulley wire take-up + high-voltage power supply
ZIGLER in-vehicle embedded	High-speed mobility + real-time processing	Dynamic pose compensation + edge computing unit
Owl indoors	No GPS + spatial constraints	Compact cabin + visual/QR positioning as a replacement for GPS, suitable for indoor environments without satellite signals

This diversity demonstrates that the HEISHA modular architecture is not merely theoretical; it has been validated through real-world testing under a variety of extreme constraint conditions. For new customers, this means that their customization requirements are likely already partially covered by some existing configuration, thereby shortening the development cycle.

10.9.9 Verifiable quantitative facts

The following facts can be directly verified and are more persuasive than vague expressions such as "years of accumulated experience":

Quantified facts	data sources
8 years of accumulated experience	Company History
12+ product formats	Product Line Statistics
44-row device compatibility list (22 brands)	Drone Compatibility Table
30 API version iterations (2025.5–2026.6)	API Documentation Version History
27 product documentation version records (May 2025 – October 2026)	Product Introduction Version History
36 patents (18 patent rights maintained; 5 pending substantive examination)	Patent List
69 three-motion module codes (MD24 + JD24 + ND21)	Structural and Transmission Modular Coding

Quantified facts	data sources
	Table
42 items parsed from the 312 functions of MSDK	Basic Version Definition Table
DNEST: 40 functional modules	DNEST Functional Table
HSC Hangar Access: 12 items + DJI Basic Edition: 35 items	HSC Functional Set
Approximately 70 technical challenges overcome	Technical Issues Checklist
PDA Medical-Grade Standard Design	PDA Debugging Tools Chapter
D90 temperature control accuracy: ±3 ℃	D90 Product Specifications
DCAP MINI operating life ≥5,000 hours	DCAP MINI Technical Specifications

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10.10 Case Writing Template (for subsequent supplementation by Heisha)

The following is a standardized case template; it is recommended that case information be collected and organized in this format for subsequent projects:

HEISHA Mining Warehouse Application Case Template

Case Number: HS-CASE-YYYY-NNN

Date of drafting: _____

Author: _____

1. project context

project	fill in
Customer Industry	□ Electricity □ Petroleum and Natural Gas □ Mining □ Public Security □ Emergency Management □Environmental Protection □Agriculture □Logistics □Scientific Research □Other ___
application scenarios	
project objective	
Existing pain points	

2. Deployment Information

project	fill in
Deployment Location	Provincial/Municipal ___ County/District
ambient condition	Temperature_℃~_℃; Humidity_%; Elevation_m; □Coastal □Inland □Plateau □Desert □Mining Area
lead time	YYYY-MM
quantity delivered	___platform

project	fill in
Operational to date	___ months

3. Plan Composition

project	fill in
product model	
Module Configuration Sheet	MD_-JD_-ND___ + ENV___ + OPT___
Compatible with drones	Brand: ___ Model: ___
Communication Solution	□4G □5G □Ethernet □Satellite □Dedicated Network
Power Supply Plan	□Municipal power □UPS □Photovoltaic energy storage □Vehicle-mounted DC
software platform	□DNEST □Customer-built □HSC + third-party

4. Technical Challenges and Solutions

throw down the gauntlet Rx effect

5. Actual operating performance metrics

metric	target value	measured value	remarks
Continuous failure-free operating time			
Temperature control accuracy			
Return-to-normal success rate			
Charging success rate			
mean time to restore			
Average annual number of operations and maintenance cycles			

6. photo of the scene

(Attached: actual photos taken after installation, including the hangar's exterior, internal layout, the state of the UAVs' parking, and the surrounding environment)

7. Customer Reviews

(Cite the client's original words or written review)

8. Customer Authorization

☐ The client has authorized the public disclosure of case information

☐ The client has reviewed the accuracy of the case content

☐ Customer name may be disclosed / □ Industry may be disclosed only / □ Fully anonymous

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Charpter 11 Technological Evolution Path

11.1 Explanation and Scope of the Evolutionary Path

The evolution roadmap outlines the direction and the path for technological investment; it does not constitute a delivery commitment. The listed R&D directions are substantiated by patent status, protocol iteration, and product form expansion; the timeline and capacity arrangements constitute a business plan and will be finalized upon project approval.

Three categories of evidence and their respective credibility assessments:

Type of Evidence	explain	reliability
Clearly articulated intent	For example, direct statements such as "We will standardize more transmission modules."	High — represents the established strategic awareness
Inventive patents pending substantive examination	Five invention patents filed for 2024–2025	High — patents serve as a leading indicator of R&D investment; the act of filing a patent application itself represents an investment of resources.
Document version update records and API iteration records	27 product documentation versions (2025.5 – 2026.10) and approximately 30 API versions (2025.5–2026.6)	High — actual action recordings are more credible than verbal plans

The reason for selecting these three categories of evidence rather than other sources is that patent applications require investment in R&D resources and agency fees, and their technical direction reflects the actual R&D priorities; version update records provide tamper-proof timestamps that reflect the actual allocation of engineering resources. Together, these two sources can delineate a more reliable outline of technological evolution than any oral plan could.

11.2 Module Library Expansion: From 69 codes to a more

comprehensive matrix

11.2.1 Clarify the intent

In the description of the active module, it is explicitly stated as follows:

Through years of tailored development within the hangar, Heisha has modularized and encapsulated certain operational modes. As the range of hangar scenarios continues to expand, so do the functional capabilities; we will further standardize more drive modules.

This statement contains two key points: 1. The current degree of modularization of the active module is "partial" rather than "full"; 2. The standardized transmission modules will continue to be expanded in the future.

11.2.2 Differences in current maturity among the three action modules

The maturity descriptions for the three types of modules exhibit clear differences:

Module Category	description	Maturity Assessment
Door actuator MD01–MD24	"The drawings and BOM have been finalized"; "the motor, drive, reducer, limit switches, and other components have all been finalized"; "the solution essentially provides comprehensive coverage for the customization needs of various hangars."	**Cured**
Mobile JD01–JD24	"The drawings and BOM have already been finalized," and "they basically cover a wide range of customization scenarios."	**Cured**
Active ND01–ND21	"Some approaches have already been modularized and encapsulated."	**Partial curing**

The active power module is a clear weak point in the three-power system. Both door power and mobile power have reached the state of "BOM hardcoding in drawings" and "basically complete coverage," whereas active power has only completed "partial" encapsulation. In light of the task differences analyzed in Section 1.3.2—such as logistics exchange, agricultural water supply, hydrogen refueling, and vertical takeoff and landing—the active power module is precisely the component with the greatest scenario differentiation and the strongest demand for customization. Therefore, completing the active power module should be the top priority in expanding the module library.

11.2.3 Recommended expansion priorities

Based on the above maturity analysis and scenario requirements, it is recommended

that the module library be expanded according to the following priority order:

priority	direction	according to	expected revenue
P0	Solidification and Completion of the Active Modules	The "clarification" component is encapsulated; the requirements for logistics and battery-swapping scenarios are the most clearly defined; ND04－ND06 (product exchange) and ND01 － ND03 (battery swapping) already have codes, but their maturity remains unclear.	Shorten the customization cycle for logistics and battery-swapping projects
P1	Quantitative Definition and Completion of Size Ranges	The finalized version provides an interval in Section 2.3.3 based primarily on the aircraft's external dimensions as the criterion; the actual coverage of the load, travel distance, and other categorized parameters across 69 combinations still requires verification.	Integrators can conduct their own preliminary screening, thereby reducing the number of communication rounds.
P2	Exploration of New Transmission Methods	In addition to the 8+8+7 transmission modes, other possible mechanism configurations may include foldable-wing storage, multi-gun magazine systems, and so on.	Cover more emerging scenarios

11.2.4 It is recommended that a module maturity labeling system be established.

It is recommended that module maturity indicators be introduced into the coding framework to help integrators quickly assess selection-related risks:

characteristic	meaning	Selection Recommendations
● Cured	The drawing BOM has been finalized and has been validated across multiple projects.	Ready for immediate selection; the shortest delivery lead time available.
◐ Parametrically adjustable	The baseline solution has been validated; fine-tuning is required based on the specific parameters.	May be used; allow a 1－2 week adjustment period.
○ Requires redesign	Where only conceptual proposals or similar case studies are available, targeted design is required.	Risks and timelines must be thoroughly assessed.

The maturity of each of the 21 active codes (ND01−ND21) is maintained according to the criteria specified in 2.4.2, with the level progressing as delivery validation advances: codes that have been delivered multiple times under the same code designation are marked ●; those requiring parameter adjustments within the project are marked ◐; and those requiring the generation of new drawings are marked ○. When requesting a quotation, the current level of the selected code should be requested directly; it is not advisable to infer the level based on the entire family as a whole.

11.3 Research Focus: Assessing Technological Investment Based on Pending Patents for Substantive Examination

11.3.1 Pending the complete list of invention patents under substantive examination

After verifying the patent list item by item, it has been confirmed that there are currently five invention patents in the "awaiting substantive examination proposal" status. The complete list is as follows:

order number	title of invention	request number	Public ID	Application Date	Applicant	Primary Classification Number
1	Drone hangars, hangar control systems, and hangar control methods	2025104790318	CN120229407A	2025-04-16	Guangdong Xinhui CIMC Special Transport Equipment Co., Ltd., Midum International Marine Container (Group) Co., Ltd., Shenzhen Heisha Technology Co., Ltd.	B64U80/70
2	UAV remote charger	2025100597364	CN119637147A	2025-01-15	Shenzhen Heisha Technology Co., Ltd.	B64U50/37
3	A fully openable and closable drone storage system	2025100274387	CN119737081A	2025-01-08	Shenzhen Heisha Technology Co., Ltd.	E04H6/44
4	A drone hangar with drone centering functionality	2024118070337	CN119611847A	2024-12-10	Shenzhen Heisha Technology Co., Ltd.	B64U70/97
5	Drone logistics airport	2024117556935	CN119551243A	2024-12-03	Shenzhen Heisha Technology Co., Ltd.	B64U70/90

11.3.2 Analysis of the technical directions addressed by the various patents

A detailed analysis of the technical directions of the five patents under development:

① Drone hangar, hangar control system, and hangar control method (CN120229407A) — Technical focus: patent portfolio development at the control system and method level; Significance: jointly filed by HEISHA and CIMC Group; the V200 container vertical hangar serves as a demonstrative product of their collaboration; Signal: control technology has advanced from hardware implementation to a methodological level. The specific details and division of labor

under this collaboration are not described herein.

② UAV Remote Charger (CN119637147A) – Technical direction: independent commercialization of charging technology – Signal: charging modules may evolve from built-in components in aircraft hangars into standalone remote-charging products, thereby expanding application scenarios (e.g., temporary field charging stations and multi-point distributed charging networks).

③ A fully openable and closable UAV storage system (CN119737081A) — Technical direction: a new form of door actuation module — Signal: In addition to the eight existing door actuation transmission methods (dual-opening smooth operation / single-opening smooth operation / dual-opening rotation / roller / single-opening rotation / lifting rotation / lifting smooth operation / vertical roller shutter), a new cover-opening configuration known as "fully openable and closable" may exist; this configuration is suitable for scenarios requiring a larger opening space, such as when large UAVs or multiple UAVs enter and exit simultaneously.

④ A drone hangar with drone centering functionality (CN119611847A) — Technical direction: innovative methods for mobile centering — Signal: centering is one of the most critical mechanical operations in a hangar (see Chapter 3 for details); this patent may propose novel technical solutions regarding centering accuracy, speed, or reliability.

⑤ Drone Logistics Airport (CN119551243A) – Technical direction: full aircraft configuration for logistics scenarios – Signal: an extension from a single hangar to an integrated logistics airport configuration, which may include dedicated logistics functions such as multiple aircraft berths, cargo transfer systems, and sorting interfaces.

11.3.3 Temporal Trends and Technology Investment Trends

The filing dates for the five patents are concentrated between December 2024 and April 2025, spanning only five months. This intensive filing pace indicates that:

2024–2025 will be a period of active investment in R&D for HEISHA.

The R&D focus is shifting from purely structural innovation toward a combined approach integrating structure, control methods, and full-system scenario integration.

The joint application with CIMC suggests that the depth of industrial synergy is deepening.

11.3.4 Implementation Benchmark for Granted Invention Patents

By way of comparison, the following granted invention patents have been implemented in products:

patent name	Authorization Publication No.	Authorization Date	Product implementation status
An intelligent drone charging station with rapid battery cooling functionality	CN114425958B	2024-04-12	Already implemented in the ACK charging system
A UAV Propeller Recovery Mechanism System	CN114408157B	2023-12-22	Implemented as active ND19–ND21 pitch mechanism + API_pulp_motor (as such) command + centering module command codes 71/72

These two cases demonstrate that HEISHA possesses a complete transformation pathway: "patent → module → protocol instructions." Patent applications are not merely a paper exercise; they have a clear path toward product implementation. This enhances the credibility of the future commercialization of patents under development.

11.3.5 Accurate representation of patent status

The status of all 36 patents held by Heisha is as follows:

Patent Type	Total	Patent Maintenance	Pending substantive review	Withdrawn/Rejected/Invalidated
patent of invention	18	2	5	11
utility model	16	15	0	1
appearance design	2	1	0	1
amount to	**36**	**18**	**5**	**13**

The detailed distribution of the status of invention patents is as follows:

state	quantity	explain
Patent Maintenance	2	CN114425958B (rapid battery cooling), CN114408157B (paddle collection mechanism)
Pending substantive review proposal	5	See the complete list in Section 11.3.1
Withdrawal of a patent application	3	Portable rooftop charging device; charging safety and fire protection in uninhabited areas; miniature weather station
Dismissed and Expired	3	Air conditioning control method, anti-theft device, integrated charging panel
Upon expiration, it shall be deemed to have lapsed.	2	Fully automated charging station equipment; fully automated conveying and charging equipment
The substantive review request shall be deemed withdrawn and invalid.	1	Design of a Fully Automated Airport Central Air Conditioning System
Dismiss other review requests	1	Remote control device for power-on and power-off

state	quantity	explain
The patent right expires upon non-payment of the annual fee; restoration is pending.	1	Portable UAV Automatic Charging Platform (CN110667426B)

For technically-oriented readers, the implications of this composition are as follows:

Active R&D investment: Five invention patents awaiting substantive review are concentrated in 2024–2025, indicating that R&D investment has been relatively strong in the recent period.

Low historical grant rate: Of the 18 invention patents, only 2 were granted and maintained (11%), while 11 have lapsed or been rejected. This may reflect that early-stage patent application strategies were not sufficiently targeted, or that the novelty/inventiveness of the technical solutions was challenged during examination.

High utility model grant rate: 15 of the 16 applications have been maintained (94%), indicating a solid accumulation of innovation at the structural design level.

Recommended attention: CN110667426B (Portable UAV Automatic Charging Platform). Although the patent was previously granted, it was terminated due to failure to pay the annual fee; if the technology still holds value, it is recommended that the possibility of reinstatement be assessed.

The complete patent register (including application numbers, legal status, and annual fee payment status) is maintained by Heisha. The statistical scope for the 36 items in this document is based on publicly disclosed patent information; consistency with the company's official register must be verified and confirmed by Heisha (see Appendix E).

11.4 The Evolution of Protocols and the Software Ecosystem

11.4.1 API Iteration Trajectory

The version history of the Heisha Ruyun API documentation shows that, from the official release of the full version of the Heisha Ruyun API on 2025-05-01 through 2026-06-22, approximately 30 version iterations have been made. The update directions can be categorized into four types:

Update direction	Representative Change	meaning
New hardware control instructions	Public address systems, infrared devices, water-collection devices, PSDK searchlights, etc.	The hangar's peripheral capabilities continue to expand.
New Equipment Integration	Fengyi drones, energy storage power	The range of compatible device types

Update direction	Representative Change	meaning
	supplies, and remote controllers moving to the cloud	is expanding.
Data structure is well-established	Supplement the physical model fields and differentiate error codes by vendor	The sophistication and usability of the agreement are improving.
Document Structure Adjustment	Integrate the full version with the basic version and restructure the sections	The maintainability and readability of the documentation are being improved.

11.4.2 Iterative Pace Analysis

Based on the temporal distribution of version records:

May−August 2025: Updates will occur almost weekly; this period constitutes an intensive development phase. This stage corresponds to the initial release and rapid refinement of the API.

September 2025 − June 2026: Average of 1−2 updates per month; the pace will stabilize. New features will primarily focus on hardware commands and device connectivity; the core protocol framework will have essentially taken shape.

This pace aligns with the typical software product lifecycle: in the early stage, rapid iteration is used to establish foundational capabilities; in the later stage, the product enters a phase of maintenance updates and incremental functional expansion. For integrators, this means that the core interfaces of the protocol have become relatively stable, allowing development to proceed based on the current version, with subsequent upgrades being primarily incremental in nature.

11.4.3 Items for further improvement

Based on a detailed review of the API documentation, the following issues need to be addressed in subsequent versions:

number	problem description	influence	Recommended priority
API-01	In the Modbus register mapping table v1.0 (2026.9.13), the columns for relative addresses, MQTT field names, parameter contents, and others are predominantly filled with the placeholder value 0.	Integrators cannot directly use the register mapping table for development.	P0
API-02	The T-series cover_state and putter_state have two separate enum definitions.	Inconsistent definitions of the same field at different locations lead to parsing ambiguity.	P0
API-03	The definitions of the air conditioner register WORKMODE (value 5 includes the constant-temperature mode) and "Operating Mode" (value 4, range 0−3) are inconsistent.	Difficulties in implementing the control logic	P1

number	problem description	influence	Recommended priority
API-04	The OSD example JSON for energy storage power supplies lacks standard common fields (tid/bid/timestamp/gateway).	The message format is not standardized across different devices.	P1
API-05	In pre_takeoff's step_key, the spelling of confirm_rainall is inconsistent with that of check_rainfall.	May cause field matching to fail	P1
API-06	The check_rainfall in the EVENT example of after_landing does not belong to the charging workflow; this appears to be a copy-paste error.	Misleading the integrator's incident handling logic	P1
API-07	The API documentation FAQ section (around line 22013) contains only the title and no content.	Common issues that cannot be resolved independently	P2
API-08	The documentation for the Remote Control Enter Cloud API describes it as a "redundant protocol, an API developed based on the legacy protocol."	Integrators may misuse legacy protocols	P2 (It is recommended that a phase-out schedule be clearly defined)
API-09	No MQTT broker address/port, TLS configuration, ClientID naming convention, authentication method, or topic QoS requirements have been provided.	Integrators cannot independently complete MQTT integration.	P0

11.4.4 Software Capability Expansion Directions

Current State and Room for Expansion of Software Capabilities:

dimension	current state	Areas for Further Development
MSDK Functional Coverage	42 out of 312 items (13.5%)	Gradually increase coverage, with priority given to high-frequency features.
Flight Control Platform	DJI MSDK/PSDK, MAVLINK (PX4, ArduPilot, INAV), Fengyi, third-party firmware packages (customization available)	Continue expanding third-party flight control support
Private deployment	DNEST supports self-deployed servers, unlimited video streaming, unlimited storage space, and direct delivery of source code.	Strengthen the private deployment capabilities of enterprise-level customers
visual power	AAR binary distribution supports only DJI MAVIC 3 E and M4E; the cloud platform business software cannot be called directly.	Platform-based visual SDK, supporting more device models and invocation methods
Source Code Delivery	HSC and DNEST provide direct source-code delivery; the Visual SDK provides AAR binary packages.	Expand the scope of source-code delivery to reduce integrators' black-box dependencies.

An MSDK coverage rate of 13.5% represents both a weakness and an opportunity. For most basic application scenarios—takeoff, landing, charging, and status reporting—the current coverage may already be sufficient; however, for advanced features—route planning, obstacle-avoidance parameter configuration, advanced camera control, and so on — many functions remain unimplemented. It is recommended that coverage be

prioritized according to the actual frequency of use by integrators, with high-frequency functions receiving priority.

11.5 Scenario and Category Expansion

11.5.1 Verified category expansion

The third FAQ question provides a clear answer: custom wired and wireless charging bays can be provided for robotic dogs, as well as custom bays for unmanned tractors and unmanned boat vessels. This aligns with the positioning of "building houses for robots."

The technical feasibility of product-category expansion is based on the universality of the modular architecture. Common requirements at the aircraft-bay level for robotic dogs, unmanned tractors, unmanned aircraft boats, and unmanned aerial vehicles include:

Storage and Protection (L0 Cabin Structure)

Automatic inbound and outbound handling (L1 drive actuation; however, the mechanical configuration may require redesign)

Charging/Battery swapping (L2 electrical energy; charging interfaces and protocols must be compatible)

Environmental control (L3: control and perception; temperature control logic is similar)

Remote control and management (L4/L5 interfaces and operations/maintenance; protocol framework is reusable)

The primary differences lie in the architectural design of the L1 layer and the charging interface of the L2 layer — precisely the variables for which the modular architecture excels.

11.5.2 The capabilities available for optional D90 expansion configurations reflect the directions in which the system can be expanded.

The optional expansion configuration options for the D90 include:

1. Photovoltaic Energy Storage Off-grid Power Supply System

2. Satellite communication terminal module

3. Wind-and Snow-Resistant Structural Reinforcement and Upgrading Kit

4. UAV Automatic Battery Swap Module

5. Local edge computing server

6. Lightning Protection System Upgrade

7. Smart Heating Module

8. Smart Cooling Module

This list reflects the areas of capability that HEISHAs is currently developing or is poised to develop:

Off-grid capability (photovoltaic energy storage + satellite communications): enables the hangar to become independent of the utility power grid and the public network, truly adapting to extremely remote scenarios.

Edge computing: deploy computing resources locally within the hangar to support real-time data processing, AI inference, and offline decision-making, thereby reducing reliance on the cloud.

Battery swap module: expanding from charging to battery swapping to shorten drone turnaround time and enable adaptation to high-frequency operation scenarios

Enhanced environmental adaptability: high-resistance wind-and-snow protection kits, upgraded lightning protection, and intelligent heating/cooling modules — these demonstrate that environmental adaptability is a direction for continuous refinement rather than a one-time design effort.

11.5.3 Morphological expansion trajectory

The version history of the product documentation reveals the actual morphological expansion actions:

time	Update Content	Direction of reflection
2026.02.04	Add parameters for suitcases and travel luggage	Portability—suited for temporary deployment and rapid-response scenarios
2026.07.22	Add detailed product information for D90	Extreme Environment Focus — Deeply Specializing in High-Difficulty Scenarios Such as Polar Regions, Mining Areas, and Deserts
2026.09.09	Add the "Energy Enhancement and Performance" section	Enhancing Energy and Performance—Improving Range and Operational Efficiency
2026.09.09	Add a modular structural component	Documenting the modular system—transforming engineering experience into transferable knowledge

time	Update Content	Direction of reflection
2026.10.22	Update product positioning	Strategic adjustment — potentially involving product category expansion or optimization of market positioning

11.5.4 Specialized Environments and Maritime Direction

D65 supports customization; IP65 and explosion-proof versions are available → suitable for scenarios with explosion-proof requirements, such as chemical, oil and gas, and mining applications

Class society certification evidence: contains 7 class society certification images (image77~83.png), but contains no textual description.

The launch of the explosion-proof version signals that HEISHA is entering industrial applications subject to rigorous safety certification. Such applications typically impose stricter equipment requirements and offer higher profit margins, but they must undergo a dedicated certification process.

The specific details of classification society certification (certification body, certification level, applicable product model, and validity period) shall be provided together with the project application. This document uses existing container certificates and joint patents solely as leads; it does not infer the certification status of the complete vessel based on these materials (see 8.5.3).

11.5.5 Collaborative Ecosystem

Patent CN120229407A was jointly applied for by "Guangdong Xinhui CIMC Special Transport Equipment Co., Ltd., Midum International Marine Container (Group) Co., Ltd., and Shenzhen Heisha Technology Co., Ltd." The V200 container vertical lift hangar is a tangible product of their collaboration.

The joint application itself indicates that Heisha and CIMC Group have established a technical cooperation relationship; the specifics of the cooperation, the division of responsibilities, and the business model fall outside the scope of this article, and readers may draw their own conclusions based on the joint patent and the V200 product form.

The collaboration with CIMC suggests two possible directions for future development: 1. Containerized hangars: Leveraging CIMC's manufacturing capabilities in the container sector and its global logistics network to develop standardized containerized hangar products; 2. Integrated specialized transportation: Deeply integrating hangars with specialized transportation equipment to achieve an integrated

"transportation + deployment + operations" model.

11.6 Areas where capabilities need to be strengthened

This section faithfully lists the existing capability gaps identified in the currently available literature. These gaps do not affect HEISHA's existing engineering capabilities, but they do impact the trust of technical readers and their decision-making in selecting solutions. An honest self-assessment is more likely to earn the trust of engineers than a hollow vision.

11.6.1 Reliability verification evidence is incomplete

System certification and product compliance certificates are already in place (ISO 9001, CE, FCC, CCC, RoHS, as well as EMC and safety test Pass reports issued by GRGTEST; see Chapter 8 for details), but the following gaps remain:

The range of tested models does not cover the entire product line: D65, D90, D200, D250, D330, V200, D007, DCAP PRO/MINI/LITE/INBUILT, energy storage cabinets, and the compliance status of the ACK series has not yet been supported by certification evidence (see Appendix E.2).

No third-party test report for the IP protection rating: the only IP54 compliance statement in the available documentation has been verified to pertain to a third party's product; therefore, it cannot serve as evidence of the protection rating for the Heisha product.

No specialized environmental adaptability tests were conducted: there are no measured test reports for high-and low-temperature exposure, temperature cycling, salt spray, dust and sand exposure, rain exposure, vibration and impact, or life-cycle testing; the only available basis is the design nominal value.

CCC certificate renewal status: pending confirmation; valid until 2026-09-29; this document had already expired at the time of preparation

RoHS report conclusion page missing: Page 309 of the report contains only the cover

Misalignment between the subject of the classification society certificate and the certificate holder: the certified object is the container shell, the certificate holder is CIMC, and there is no evidence that the aircraft hangar has obtained full acceptance status (see Appendix E.2).

For technically-oriented readers — particularly structural and electrical engineers from the customer side — reliability verification data serves as a critical basis for component selection decisions. Without such data, even if a product has actually passed certification, it will not be accepted during the technical review. It is recommended that priority be given to completing the required data (see Section 8.9 for the priority order for completion).

11.6.2 Engineering knowledge has not been systematized into written form.

The "Technical Challenges to Be Overcome" list documents approximately 70 real-world engineering problems; however, no solutions to any of these problems have been provided in the existing literature.

This is the most regrettable waste of assets. Approximately 70 issues are the direct product of eight years of engineering experience; each one has a corresponding solution and design improvement. If these solutions can be documented, they will serve as: -the ideal training material for new employees; -a reference manual for integrator troubleshooting; -input for iterative module design; and-the most compelling evidence of reliability in white papers.

11.6.3 Lack of production capacity information

Only factory photos and factory video links are provided; there is no quantitative data regarding production capacity, site area, equipment inventory, staffing, or delivery lead times.

For integrators engaged in bulk procurement, a supplier's production capacity is a key consideration for supply chain security. Without this information, integrators cannot assess whether HEISHA can meet their delivery schedule requirements.

11.6.4 Key selection parameters are missing

The "large/medium/small" size classes for the three-motion module originally had no quantitative definition; the final version now provides quantitative ranges in sections 2.3.3 and Appendix A.5, using the overall dimensions of takeoff and landing as the primary criterion, while classification parameters such as load and travel distance still need to be further refined according to the module atlas.

Apart from the fact that the D65 door opening/closing time is ≤ 30 seconds per

cycle and the DCAP MINI service life is ≥ 5,000 hours, there are no other key selection parameters such as driving torque, motor power, positioning accuracy, or cycle life.

The size range has been provided, but the performance parameters remain incomplete; as a result, integrators cannot yet fully complete the initial module selection independently during the design phase and still partially rely on the manual selection support provided by Heisha.

11.6.5 Module maturity has not yet been identified on a per-code basis.

The description for "door movement and actuation" is "the drawing BOM has been finalized"; the description for "actuation capability" is "partially encapsulated"; however, there is no maturity indicator indicating that each item has been individually coded.

When selecting components, integrators need to know which modules can be adopted directly (short delivery cycle, low risk), which require parametric adjustments (moderate cycle), and which necessitate redesign (long cycle, high risk). Without this information, each project must be evaluated from scratch, thereby increasing communication costs.

11.6.6 Lack of detail in intelligent capabilities

The mentioned intelligent capabilities include five temperature-control capabilities, three vision capabilities, and three fire-protection capabilities; however, each consists only of a high-level heading and lacks detailed technical parameters, implementation methods, or interface specifications.

11.6.7 Missing customer case data

The available records contain no customer names, project locations, delivery dates, delivery quantities, or measured operational data.

For technically-oriented readers, a genuine customer case study — including the deployment environment, uptime, failure rate, and maintenance records — is more persuasive than ten pages of technical specifications. It is recommended that, without violating confidentiality agreements, you compile 3–5 representative case studies.

11.6.8 Inconsistent product specifications

The following parameters are in conflict:

product	Parameter items	Conflict value	Location of occurrence
D200	power	2000W / 2800W / ≤2800W / ACK module 3000W	multiple
D80	power dissipation	Power consumption: 500 W vs. product page: ≤800 W	Two locations
D135	power dissipation	2400W/1200W vs ≤2800W	Two locations
D330	Compatible devices	"Yuan Du 13V" (this way) vs. "Yuan Du Lingxun ZT-25V"	Two locations
High-current relay	weight	"99" unit missing	One location

Inconsistent parameters are a major pitfall in technical documentation. For engineers engaged in system selection, uncertainty regarding a single parameter can lead to a complete reevaluation of the entire solution. It is recommended that, in the next version of the documentation update, priority be given to correcting all conflicting parameters.

11.6.9 Data quality defects

In the compatibility list, the "XXX" placeholder under the Kediwei brand has not been replaced.

11 brand names for non-invasive devices (Bainazhixing, Danateq, Aidrone, Drone, Geofencing, Heptaairborne, Skyeair, Droneexpress, Infovision, Italdron, Accelligence)

It states that the categories are "mainly divided into six major groups," but in practice only five numbered items are listed.

The VIP price list format is confusing

The "D135" Standard and Certification section appears twice.

"#### Customized Innovation" as a hollow title

No textual description for the owl indoor unit storage room.

11.6.10 Priority recommendations for completion

priority	Missing items	Reason
P0	Reliability verification data (certification reports, test reports)	Directly affects the customer's

priority	Missing items	Reason
		technical review approval rate
P0	Solutions to approximately 70 engineering issues	The most valuable engineering asset is currently being completely wasted.
P0	Correction of inconsistencies in product parameters	The Foundation of Data Credibility
P1	Quantification of Key Selection Parameters (dimensional range definition, performance parameters)	Prerequisites for integrators to make independent component selections
P1	Module maturity grading (individual coding and identification)	Reduce communication costs associated with equipment selection
P1	Complete the Modbus register mapping table	Prerequisites for integrator development
P2	Quantitative data on production capacity	Basis for Supply Chain Security Assessment
P2	Customer Case Studies (3−5 Representative Cases)	Enhance credibility and persuasiveness
P2	Data Quality Defect Remediation	Basic Requirements for Document Professionalism

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11.7 Summary of Recommended Evolutionary Pathways

11.7.1 Recommended Summary Table

The recommendations from Sections 11.2−11.6 are summarized as follows:

direction	Specific Recommendations	priority	according to	expected revenue
Module Library Expansion	Activation Module Consolidation and Completion (individual maturity assessments for ND01−ND21)	P0	"Partial packaging"; clear demand for logistics and battery swapping	Shorten the customization cycle for logistics-related projects
Module Library Expansion	Quantitative definition of size ranges (specific parameter ranges corresponding to large/medium/small)	P1	The range has been determined; the tiered parameters are yet to be refined.	Integrators may conduct their own preliminary screening.
Module Library Expansion	Implementation of the Module Maturity Framework (Code-by-Code Ledger)	P1	Rules and clan-specific identifiers have been established; the code-based ledger is yet to be developed.	Reduce selection risks
Protocol refinement	Fill in placeholder values in the Modbus register mapping table	P0	A large number of fields are 0	Integrators can develop directly
Protocol refinement	Standardize enumeration definitions, correct spelling errors, and complete the MQTT	P0−P1	Multiple inconsistencies and omissions	Reduce joint debugging issues

direction	Specific Recommendations	priority	according to	expected revenue
	connection parameters			
Protocol refinement	Define a clear phase-out schedule for the legacy remote-control-to-cloud protocol.	P2	The document describes itself as a redundant protocol.	Prevent integrators from misusing the feature
Software Extension	MSDK functional coverage increased (currently 13.5%)	P1	A wide range of high-frequency functions are not covered	Reduce the workload for integrators' in-house development
Software Extension	Visual SDK Platformization (breaking through the binary constraints of AAR)	P2	Currently, only 2 device models are supported.	Expand the scope of application for visual capabilities
Complete documentation	Reliability verification data (certification reports, test reports)	P0	The certification section contains no content.	Pass the customer technical review
Complete documentation	Documentation of solutions to approximately 70 engineering issues	P0	The most valuable engineering assets have not yet been capitalized.	Knowledge reuse, training, and troubleshooting
Complete documentation	Correction of Inconsistencies in Product Parameters	P0	D200/D80/D135/D330: multiple conflicts	Data credibility
Complete documentation	Quantitative data on production capacity	P2	Only photos, no data	Supply Chain Security Assessment
Complete documentation	Customer Case Studies (3–5)	P2	No case data available	Enhance persuasiveness
Product Category Expansion	Standardization of robotic dogs, unmanned tractors, and unmanned vessel launchers	P2	FAQ: Confirmed as feasible	Expand market opportunities
Product Category Expansion	Standardization of explosion-proof versions (customization precedents already exist for D65)	P2	Demand in chemical, oil & gas, and mining applications	Enter high-value industrial scenarios
ecological construction	Deepening Cooperation with CIMC (Containerized Garage)	P2	Joint Patent + V200 Empirical Validation	Scale and Globalization

11.7.2 Three temporal perspectives

The following items are assigned relative priorities based on the strength of the evidence; they do not correspond to specific dates or quarters:

Recent initiatives (completeness improvements) — Address current document and data quality issues and eliminate integration challenges for integrators: complete the Modbus register mapping table; correct inconsistencies in product parameters; complete

reliability verification data; document solutions for approximately 70 engineering issues; rectify spelling errors and inconsistencies in API documentation; and quantify key selection parameters (define size ranges).

Mid-term (Extended Phase) — Expand the module library and software capabilities to improve customization efficiency and coverage; solidify active modules one by one and assign maturity indicators; increase MSDK functional coverage; platformize the Visual SDK; establish a module maturity indicator system; make production capacity data publicly available; and compile customer case studies.

Long-term (ecological model) — Expand product categories and market reach; establish influence in industry standards — Extend product categories to include a wider range of robotic forms (robotic dogs, unmanned tractors, unmanned boat vessels); open an interface ecosystem (third-party flight control systems, third-party sensors, third-party cloud platforms); participate in the development of industry standards (aircraft hangar interface standards, charging interface standards, communication protocol standards); and promote the standardization and globalization of containerized aircraft hangars.

11.7.3 Advice for Integrator Readers

Within the current capability boundaries of HEISHA, a prudent technology selection should be made by following the principles below:

1. Prioritize modules that have already been finalized: the BOM drawings for the door-driven MD01−MD24 and motor-driven JD01−JD24 have been finalized, resulting in the shortest delivery lead time and lowest risk. For active modules, the maturity status of the specific code must be confirmed before component selection.

2. Reserve time for joint debugging: When initially integrating with the Heisha API, it is recommended to set aside 2−4 weeks for joint debugging to address discrepancies in protocol interpretation and environment compatibility issues.

3. Define the power budget: Complete a detailed power consumption budget during the RFI phase (see Chapter 4 for details) to avoid rework caused by insufficient on-site power supply. Pay particular attention to peak power in scenarios involving multiple devices operating concurrently (charging, temperature control, communication, and sensors operating simultaneously).

4. Early validation of multi-device concurrent operation scenarios: Among the "technical challenges to be addressed," several relate to multi-device concurrent operation

(e.g., "when the DCAP remote controller and a drone charge simultaneously, the entire system shuts down"); it is recommended that such scenarios be identified and validated during the system design phase.

5. Stay tuned for API version updates: APIs are continuously being iterated upon, so we recommend subscribing to version update notifications to promptly receive information about new features and bug fixes.

6. Make full use of the RFI checklist: The RFI checklist in Chapter 9 is a key tool for avoiding requirement omissions; it is recommended that it be completed item by item and confirmed by both parties during the project initiation phase.

11.8 epilogue

The central argument of this article can be summarized in three sentences:

Modularization makes customization predictable: with 69 three-dimensional motion module codes, a six-layer technical architecture, and a unified interface protocol, aircraft hangar customization has shifted from "redesigning every order" to "selecting modules + combining them + parameterized adjustments," making delivery cycles and reliability predictable.

A unified interface makes integration reproducible: all aircraft fleets share a single API, and all UAV models share a single API; as a result, an integrator's development deliverables can be reused across different projects, causing marginal integration costs to decline.

Eight years of real-world engineering experience provide a solid foundation for reliability: 36 patents, 44 lines of aircraft model compatibility, approximately 70 documented real-world engineering issues, over 12 product variants, and 30 API version iterations—these are verifiable achievements, not marketing rhetoric.

At the same time, this article candidly identifies current shortcomings: solid technical capabilities exist, but the level of documentation lags behind engineering capabilities; reliability verification data is missing; solutions to engineering issues have not been systematically documented; performance parameters for component selection remain incomplete; module maturity has not yet been identified on a per-code basis; and product parameters are inconsistent. These shortcomings do not undermine Heisha's engineering capabilities, but they do affect the trust of technical readers and the efficiency of component selection. Addressing these gaps is not only essential for

Heisha's own development but also a demonstration of responsibility toward its integrator customers.

This document has been prepared based on available information as of October 2026. Technology and products continue to evolve; when using the content of this book, please refer to the latest versions of the product documentation and API documentation.

Appendix A: Quick Reference Table for Three-Motion Module Coding

This appendix summarizes the coding systems described in Chapters 2 and 3 for quick reference during model selection and quotation requests. The three-motion coding comprises 69 codes in total: 24 for door motion, 24 for motorized motion, and 21 for active motion; each code is uniquely identified by the combination of "transmission method × size class."

A.1 Door actuator module MD01−MD24

"Door actuation" refers to the method by which the hangar door is operated. Whenever a hangar has storage functionality, this component must be custom-made.

driving mode	big	Midum	small
Double smoothness	MD01	MD02	MD03
Single-opening smoothness	MD04	MD05	MD06
Double-opening rotation	MD07	MD08	MD09
expansion cylinder	MD10	MD11	MD12
Single-opening rotation	MD13	MD14	MD15
Lift and rotate	MD16	MD17	MD18
Smooth elevation	MD19	MD20	MD21
Vertical roller shutter	MD22	MD23	MD24

Module status: Drawings and BOM have been finalized; the motor, drive, reducer, limit switches, and other components have been finalized.

A.2 Mobile Modules JD01−JD24

Mobility refers to the movement mechanism of a drone within the hangar.

driving mode	big	Midum	small
Return to the center	JD01	JD02	JD03
Return bias	JD04	JD05	JD06
Translation	JD07	JD08	JD09
promotion and demotion	JD10	JD11	JD12
Horizontal rotation	JD13	JD14	JD15
Vertical magazine	JD16	JD17	JD18
Rotating magazine	JD19	JD20	JD21
Gravity Realigns	JD22	JD23	JD24

Module status: Drawings and BOMs are now finalized, providing basic coverage for a wide range of customization scenarios.

A.3 Active Modules ND01−ND21

Actuators refer to the functional actuation mechanisms of a drone.

function	big	Midum	small
Three-axis battery swap	ND01	ND02	ND03
Three-axis replacement	ND04	ND05	ND06
Three-axis hydrogenation	ND07	ND08	ND09
Height adjustment and exchange	ND10	ND11	ND12
Robotic Arm Battery Swapping	ND13	ND14	ND15
Water addition mechanism	ND16	ND17	ND18
Paddle mechanism	ND19	ND20	ND21

Module status: Some approaches have completed modular encapsulation, and continue to be standardized as use cases expand; code-level maturity is maintained in accordance with the rules specified in 2.4.2 (see 3.7).

Note: The term "function" in the table is the wording used in the original table header and is synonymous with "actuation." Actuation comprises 7 modes × 3 ranges = 21 codes; door actuation and power actuation each comprise 8 × 3 = 24 codes.

A.4 Encoding Structure Description

Rank	short-cut process	meaning
Letter block	MD / JD / ND	Door-operated / Motorized / Actuated
Section Number	01–24（MD、JD）、01–21（ND）	Transmission type × size class unique identifier

The numbering sequence follows this pattern: the three size classes for a given transmission method are consecutively numbered (large → medium → small); transmission methods are arranged according to the row order in the table.

A.5 Size Range Description

Large/Medium/Small categories are defined according to the quantitative criteria in Section 2.3.3, using compatibility with the unmanned aircraft's takeoff and landing envelope as the primary criterion—the larger of the landing gear envelope and the blade-outspan diameter shall be used: for the small category, landing gear envelope ≤ 500 mm

and blade-outspan diameter ≤ 600 mm; for the medium category, landing gear envelope $500-900$ mm or blade-outspan diameter $600-1100$ mm; for the large category, landing gear envelope ≥ 900 mm or blade-outspan diameter ≥ 1100 mm. Boundary cases are classified after verifying the net opening dimensions of the fuselage and the centering travel; the criterion values shall be selected from the range accepted by the engineering community, while actual coverage shall be determined by the module catalog.

Appendix B: Product Lineup and Summary Table of Key Parameters

B.1 Product Portfolio

class	product model
Ground-fixed Series	D65、D80、D100、D135、D200、D250
Specialized for extreme environments	D90
Vehicle Series	DCAP, DCAP PRO, DCAP MINI, DCAP LITE, DCAP INBUILT, vehicle modification, in-vehicle embedded garage, in-vehicle embedded system (ZIGLER)
Portable Series	D007 Stowed Aircraft Hangar
Fixwing/Logistics Series	D330 vertical hangar (Yuandu), V200 container vertical hangar
Indoor Collection	Owl indoor unit warehouse and indoor warehouse inspection
Special Series	Customized tethered hangar solutions; customized DPAD centering charging boards
Charging and Auxiliary Power	ACK150, ACK800, ACK2000, UAV charging stand, remote-control control board, remote-control base, high-current charging output relay, self-developed RTK base station, HEISHA energy storage cabinet
software product	HSC, DNEST, Visual SDK AAR, PDA debugging tools, Q100 aircraft depot remote operations and maintenance platform

B.2 Comparison of Key Parameters

model	Closed dimensions	Open dimensions	net weight	levels of protection	working temperature	Compatible devices	supply electricity
D65	672.8×664×645mm	Maximum unfolded length: 1570 mm	62.5kg	IP55	-10 ℃ ~+50℃	—	AC220V ± 15%
D80	1109×900×1020mm	1109×900×558mm	93.8 kg (main unit)	IP54	-20 ℃ ~+55℃	Mavic 3E/T 、Matrice 4E/T	AC220V / 800W
D90	1550×1550×1740mm	—	500kg	IP65	-40 ℃ ~+65℃	Suitable size for industrial multirotor/rocket-style drones	AC220V ± 20%
D100	1200 × 890 × 1034mm	1200 × 890 × 710mm	95kg	IP54	-20℃~50℃	DJI M30, Kediwei	AC100~240 V / 800W
D135	1638 × 1251 × 1599mm	1638 × 1251 × 1037mm	248kg	IP54	-20 ℃ ~+55℃	Matrice 350 RTK	AC220V / 2800W
D200	—	—	515kg	IP54	-20 ℃ ~50℃	Matrice 400, Fengyi Ark 20	AC220V / 2800W
D250	2500×2400×1500mm	4600×2400×1500mm	450kg	—	—	Ark 20	—
DCAP	132×88×40cm	202×88×40cm	45kg	IP54	-10℃ ~+45℃	Mavic 3E/T、Matrice	DC12V / 120W

model	Closed dimensions	Open dimensions	net weight	levels of protection	working temperature	Compatible devices	supply electricity
DCAP PRO	1850×1050×356mm	2850×1050×356mm	99kg	—	—	4E/T DJI M30	—
DCAP MINI	1360×750×280mm	1360×1480×280mm	67kg	IP54	0℃~55℃	2S-4S compatible	DC24V / ≤ 150W
DCAP LITE	710×650×330mm	1320×650×330mm	40kg	IP54	-5℃~50℃	DJI M3E, M4E	AC100~240 V / 250W
DCAP INBUILT	customizable	customizable	34kg	—	-5℃~50℃	customizable	12V/24V / 120W

The dimensional units and formatting in the table are reproduced verbatim from the product documentation; "—" indicates items for which the documentation does not provide information, which are listed separately in Appendix E. D200: Power specifications are inconsistent across multiple sources (2000 W/2800 W/3000 W); the table adopts the full-unit input power value; see Section 4.4 for details.

Appendix C: UAV Compatibility Checklist

The complete compatibility record comprises 44 rows, covering brands such as DJI, Fengyi, Kediwei, SKYDIO, AUTEL, AEROSENSE, AERBORNE, Flaredynamic, XER-TECH, PROTEC, T-MOTOR, DRONEGY, Yuandu, and Tiantu. The three levels of compatibility depth are defined as follows.

Compatible gear	meaning
Custom Aircraft Hangar	The hangar structure and transmission system are compatible with this aircraft model in terms of fuselage dimensions and centering travel.
Customized charging and accommodation	Based on the aircraft hangar customization, complete the integration of the charging interface with charging management.
Customized Software Deployment	Building on the previous two stages, complete the integration between Ruyun Software and the dispatching system.

The complete list is provided in Section 6.5. In the list, one model name is a placeholder (the Codewye entry), and 11 brands are registered only as brand names without corresponding model names; their level of compatibility is assessed based on the custom configuration in the model library, while quality issue analysis is presented in Section 6.5.2.

Appendix D: Revision History

edition	date	Revisions
V0	2026-11-02	First edition. Completed the main text of 11 chapters and four appendices; established a six-tier technical architecture and a three-module coding framework.
V0.1	2026-11-03	Remove procedural content and clean up content source markers; reorganize the appendices into a quick-reference table, a master product parameters table, an adaptation checklist, and a revision record.

edition	date	Revisions
V1.0	2026-11-05	Finalized version. Complete all outstanding content required for the main text and tables; standardize format dimensions, maturity levels, modification levels, and power ratings; restructure Appendices A−D into structured chapters; and add Appendix E, a checklist of data awaiting verification.

Subsequent revisions are added here.

Appendix E: List of Data Pending Verification

This checklist lists items marked with "—" in the main text or those for which third-party evidence has not yet been obtained; these items are grouped by category. When selecting equipment, submitting bids, and conducting acceptance inspections, integrators may use the listed items as a checklist of documents that must be requested from Heisha or a third-party institution; prior to obtaining the following documents, the relevant items shall be accepted based on the "design claims" rather than the "verification conclusions."

E.1 Environment and Reliability Verification

Verification Item	Products involved	Documents required for submission	use
High-and low-temperature operation and temperature cycling	D65、D80、D90、D135、D200、D250、D330、V200	Third-party test report (GB/T 2423 or IEC 60068 series)	Bidding and Technical Review for Extreme Cold/Extreme Heat Projects
Salt spray corrosion	Coastal deployment models (D90, D135, etc.)	Neutral salt spray report (ISO 9227), corresponding to the C4-M grade	Salt Spray Environment Corrosion Protection Commitment
Dust/Sand Protection	D90 and other models designed for extreme dust conditions	IP5X/IP6X Test Report (GB/T 4208)	Mining areas and desert projects
Rain Exposure and IP Protection	Full range (D90 nominal IP55, D135 IP65, D200 IP54)	IP Rating Test Reports for Each Model	External Commitment Regarding Protection Rating
Wind Resistance and Structural Wind Load	D65, D90 (including structural reinforcement kit)	Wind tunnel test report or structural wind load calculation report	Typhoon-prone areas and coastal projects
Snow load	D90 Four-Slope Slanted-Roof Structure	Structural calculation report or loading test records	High-latitude and polar programs
Service life and durability cycles	DCAP MINI (≥5,000 hours), etc.	Open/Close/Return-to-Center/Charging Cycle Count Test Record	Durability Commitment for High-Frequency Operations Projects
Vehicle Vibration and Shock	DCAP series and in-vehicle embedded solutions	ISO 16750-3 or an equivalent vibration spectrum test report	Vehicle modification project
Transportation and Lifting	Full range	Packaging and Transportation Vibration and Drop Test Records	Delivery and Installation Acceptance
Explosion-proof certification	D65 Custom Explosion-Proof Version	GB 3836 or ATEX/IECEx certification	High-Risk Area Project
Class Society full-ship certification	V200 and Container Configuration Options	Class society full-plant certificate or type approval	Maritime/Shipboard Projects

E.2 Certification and Compliance

project	present situation	Documents required for submission
CCC Renewal Certificate	No.2021010907421117, valid until 2026-09-29; has expired	The certificate issued upon renewal or the certificate of acceptance for certificate replacement
RoHS Conclusion Page	Report S23021200101E,309 pages in total; the available material currently shows only the	Complete report or conclusion page (results for 10

project	present situation	Documents required for submission
	cover.	substances)
Wireless Module Certification	The hangar is equipped with a 4G/5G module; Part 15B states that it does not cover the module's own certification.	Module Manufacturer FCC ID and Certification Documents
Model coverage	Current certifications cover D60/D80/D135/DNEST/DCAP	Corresponding certificates for models such as D65, D90, D100, D200, D250, D330, V200, and D007
Registered address consistency	Inconsistencies between the RoHS report, ISO 9001/CCC, and CE/FCC addresses at three locations	Comparative Explanation of the Business License and the Addresses Listed on the Various Certificates

E.3 Product Parameter

Parameter items	Products involved	explain
Standby power consumption	D100、DCAP MINI、DCAP LITE、DCAP INBUILT、DCAP PRO、D250、D90、V200、D330	The documentation provides only the operating/maximum power; no value is given for standby power consumption.
Opening and closing dimensions	Open dimensions of D200 and D90	Complete the product drawings with the required annotations
Single-piece dimensions	ACK2000, high-current charging output relays, etc.	Only visual diagrams are provided; no text or numerical data is included.
levels of protection	D250、DCAP PRO、DCAP INBUILT	Not provided on the product page; see Appendix B.2.
Operating temperature and humidity	Operating humidity range for D250; D80/D135/D200	Not clearly stated on the product page
Air Conditioning and Temperature Control Parameters	D250 (compressor air conditioner + temperature and humidity sensor)	Cooling capacity, power, and noise levels are not provided.
Air ducts and fans	Full range	There are two types: side-air supply and overhead-air supply; the specific specifications are determined based on the heat load calculation.
classification of wind resistance	D90 and models other than the D65	Based on the structural calculation report
Safety Specifications for Hydrogenation and Water Addition Modules	ND07–ND09、ND16–ND18	Review of project explosion protection and piping schemes
D200 power aperture	D200	With 2000W/2800W/3000W operating simultaneously, this article uniformly adopts a total system input of 2800W; this will be confirmed later.
T-series status enumeration	T-Series Hangar	cover_state/putter_state: two sets of definitions coexist; synchronization with the firmware and mapping table is pending.

E.4 Business and Project Information

project	explain
Delivery Volume and Client List	The data are described qualitatively as "massive"; there is no data on delivery quantities, customers, or project locations.
Capacity and Delivery Cycle	Production line, production capacity, standard lead time, and peak capacity have not been provided.

project	explain
Quantity Discounts and Mold Dilution Threshold	In the absence of quantitative data, this paper provides only qualitative inference.
after-sale serviceSLA	Arrival time, repair time, spare parts lead time, and service center locations have not been provided.
VIPprice list	The correspondence between regions and price tiers is misaligned and needs to be reorganized.
Actual field test data from customer cases	The number of successful flights, cycle time per flight, and fault intervals must be measured by the customer and documented in writing.

E.5 Engineering and Knowledge Documentation

project	explain
Solution to each engineering issue	Approximately 70 records contain only problem descriptions; the corresponding corrective actions are part of internal technical documentation.
Coding-Level Maturity Register	ND01−ND21: Each code level must be maintained in accordance with Rule 2.4.2 and made available externally.
Module Drawings and Configuration List	Dynamic parameters such as travel, torque, and motor power shall be subject to the module drawings.
Complete address allocation for the agreement	In mapping table v1.0, relative addresses, MQTT field names, and other fields are set to placeholder values.
Patent Register	Items 36: Statistics are based on publicly available information and should be verified against the company's official records.
Peripheral Device Instruction Set	For equipment such as energy storage power supplies, there is no services_reply; actual testing is required to confirm that the command is usable.
Indoor unit storage, DPAD, vehicle modification	Only image or video materials are available; the specification sheet is missing.
Items pending addition to the compatibility list	Koddiway's flagship models and the specific model names of 11 brands

Recommended approach: E.1 and E.2 determine the technical credibility of commitments made to external parties; it is recommended that priority be given to obtaining these documents; E.3 and E.4 determine the accuracy of equipment selection and quotations; these may be provided to clients on a project-by-project basis as needed; E.5 pertains to internal documentation, and its external disclosure should preferably take the form of excerpts and summaries.