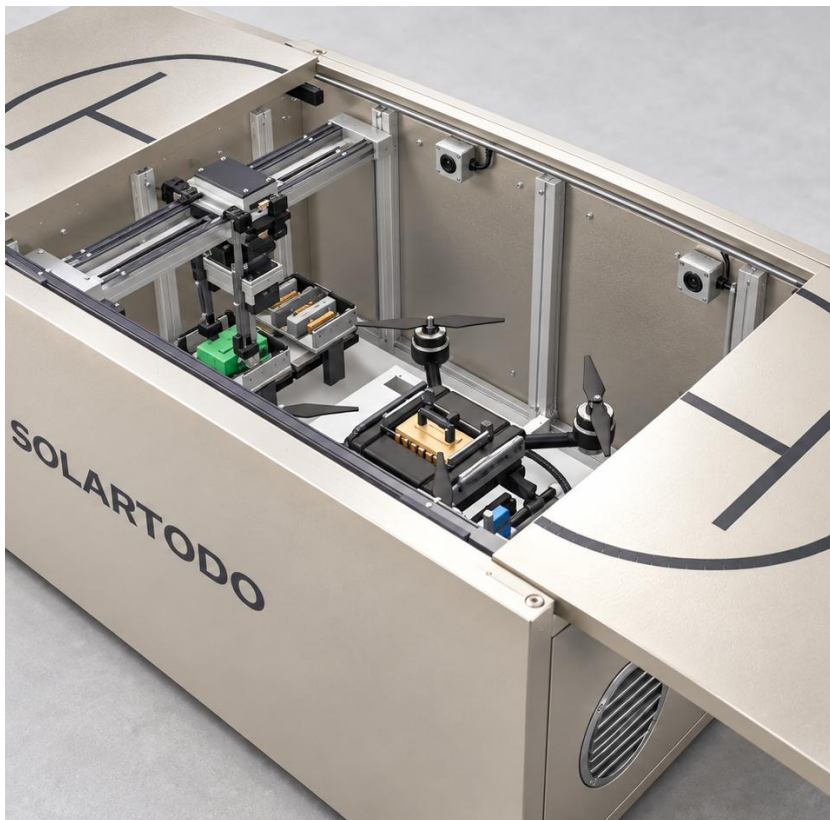


Air-Ground Coordinated System

Complete Product, Technical, Operator and Maintenance Manual



One coordinated product family: the STT 1S MAX UAV, STT-HUB1101 autonomous battery exchange hangar, and STTBOT-S1 / STTBOT-T1 humanoid ground robots.

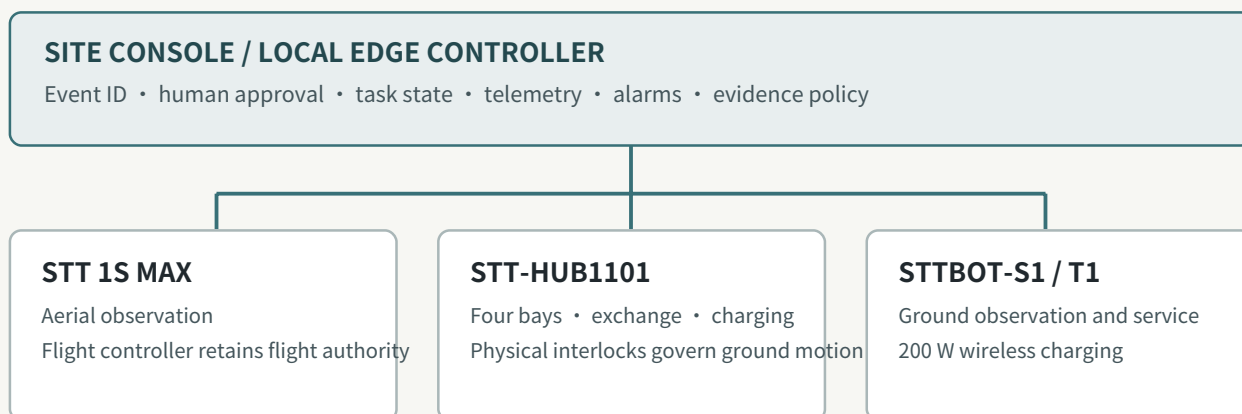
Contents and Use

Part	Product section	Subjects
I	System package	Product identities, included functions, configuration record, authority boundaries
II	STT 1S MAX	Aircraft function, geometry, energy, controls, mission operation, alarms and care
III	STT-HUB1101	Four-bay hangar, charging, exchange, HMI, operating cards and fault recovery
IV	STTBOT-S1 / STTBOT-T1	Model comparison, mobility, perception, 200 W charging, controls, alarms and maintenance
V	Air-ground coordination	City inspection, detection, authorized response, mission data, dispatch, dashboards and service analytics
VI	Site operation	Daily/periodic checks, incident response, configuration and handover forms

This document covers the independent, four-bay STT-HUB1101 installation, its matched exchange aircraft and the STTBOT ground robot supplied with the air-ground system. STTBOT-S1 and STTBOT-T1 share an exterior design language but have different dimensions and operating specifications. The delivery record identifies the supplied robot model, quantity and options.

Product images identify appearance and operating zones; specification tables define dimensions and performance. The supplied-unit configuration record identifies serial numbers and fitted options.

One mission record across air, dock and ground



Each asset reports its own readiness and faults; no console command overrides a local safety condition.

I. System Package

I.1 Product identities and supplied functions

Product	System role	Essential interface
STT 1S MAX	Aerial observation and approved inspection missions; returns to the hangar for battery exchange	Matched 6S battery module, aircraft identity, flight readiness and mission telemetry
STT-HUB1101	Receives the aircraft, manages four battery bays, exchanges and charges modules, and confirms ground-side handover	Aircraft retention, ground propulsion inhibit, battery identity and independent physical feedback
STTBOT-S1	Compact humanoid ground observation and service tasks	Robot identity, local perception, task state and 200 W wireless charging
STTBOT-T1	Larger humanoid ground observation and service tasks	Robot identity, local perception, task state and 200 W wireless charging
Site console and edge controller	Presents one event timeline and the authorized control path across assets	Task approval, telemetry, alarms, local evidence and data policy

The core air-ground delivery configuration includes one exchange UAV, one STT-HUB1101 cabinet, four matched aircraft batteries and one STTBOT ground robot selected as S1 or T1. One battery is installed in the aircraft and three are stored in the cabinet, leaving one bay empty for the returning module. The order and delivery record identify the selected robot model and any additional robots. Each supplied robot has its own wireless charging position; robot charging does not use a hangar battery bay.

I.2 The complete operational loop

1. The site console opens or receives an event with a shared event ID and location.
2. An operator reviews the need for aerial or ground observation and checks current asset readiness.
3. Required site and flight permissions are recorded before a task is released.
4. The UAV and/or a selected STTBOT robot executes the approved task while reporting progress, battery and link state.
5. The UAV returns to STT-HUB1101; the cabinet secures it and exchanges its matched battery only after physical guards pass.
6. A robot returns to its own charging position when its energy policy requires it; the 200 W wireless link starts only after alignment and BMS permission.
7. The operator reviews findings, alarms and evidence references and closes the event record.

Coordinated task lifecycle



A shared event ID links approvals, air and ground tasks, recovery, alarms and the final evidence record.

I.3 Independent authority and safety

The aircraft flight controller is responsible for flight stability, preflight checks and flight control. The hangar controller governs ground mechanisms and battery transfer. The robot controller governs balance and local motion. The site console submits and records approved task requests; it does not substitute for any local safety interlock. Takeoff, restricted-area entry, significant route changes and physical robot intervention require the applicable site authority and operator decision. Loss of a remote link does not silently authorize an action.

Decision	Confirmed by	Required record
Dispatch an aircraft	Site operator and aircraft flight checks	Event ID, aircraft ID, area/airspace clearance, route version
Start a hangar exchange	Hangar physical guards and eligible module	Aircraft/module IDs, receiving bay, each confirmed exchange stage

Decision	Confirmed by	Required record
Dispatch a ground robot	Site operator and robot readiness	Robot model/ID, area, task and operator
Start robot wireless charging	Dock alignment, foreign-object check and BMS permission	Robot ID, charge session and fault state
Export selected event media	Customer data policy and authorized role	Approved event frame or clip, reason, time range and recipient

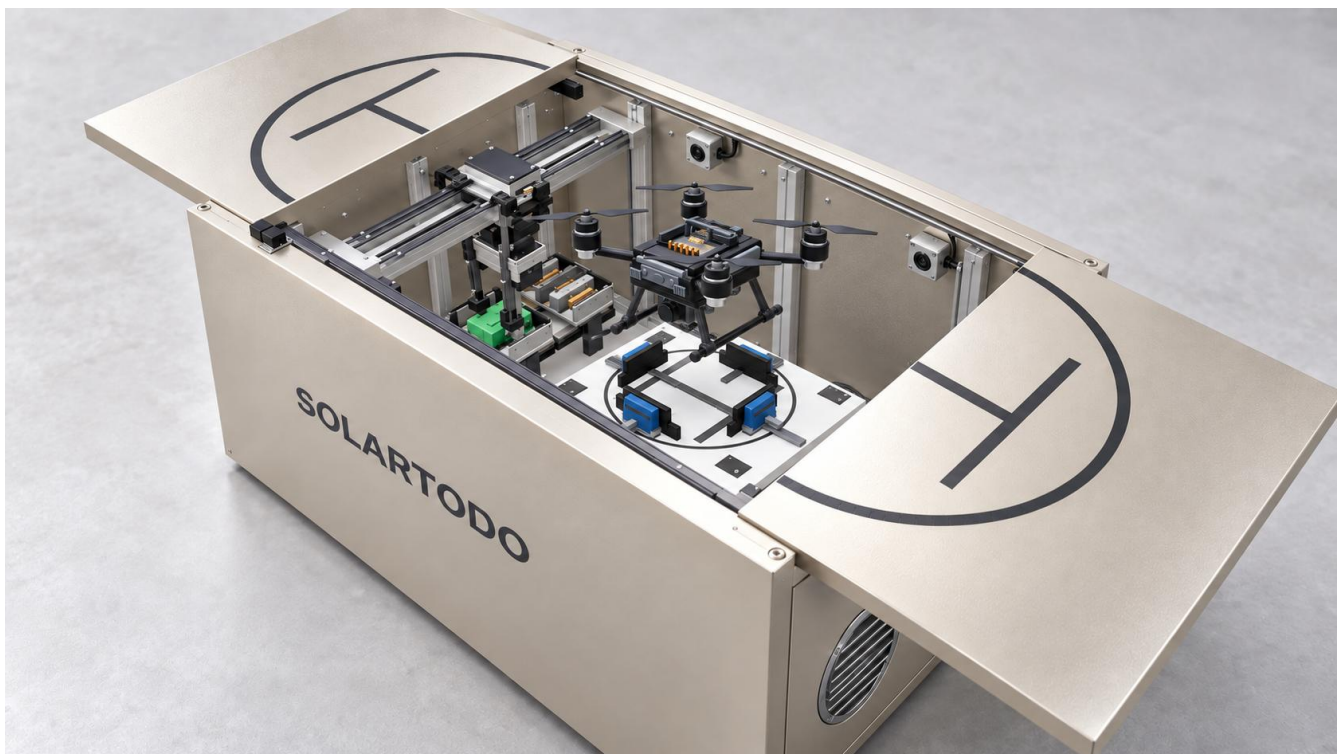
I.4 Configuration record

Every site receives a configuration sheet listing the cabinet serial number, aircraft identity, four battery IDs, robot model and serial number, robot battery configuration, software versions, mission camera configuration, local-network identity, charging positions and authorized operators. The tables in this manual describe the family; the configuration sheet identifies the exact supplied set.

PART II

STT 1S MAX

Aerial observation, matched battery exchange and controlled mission return.



The aircraft within the four-bay hangar.

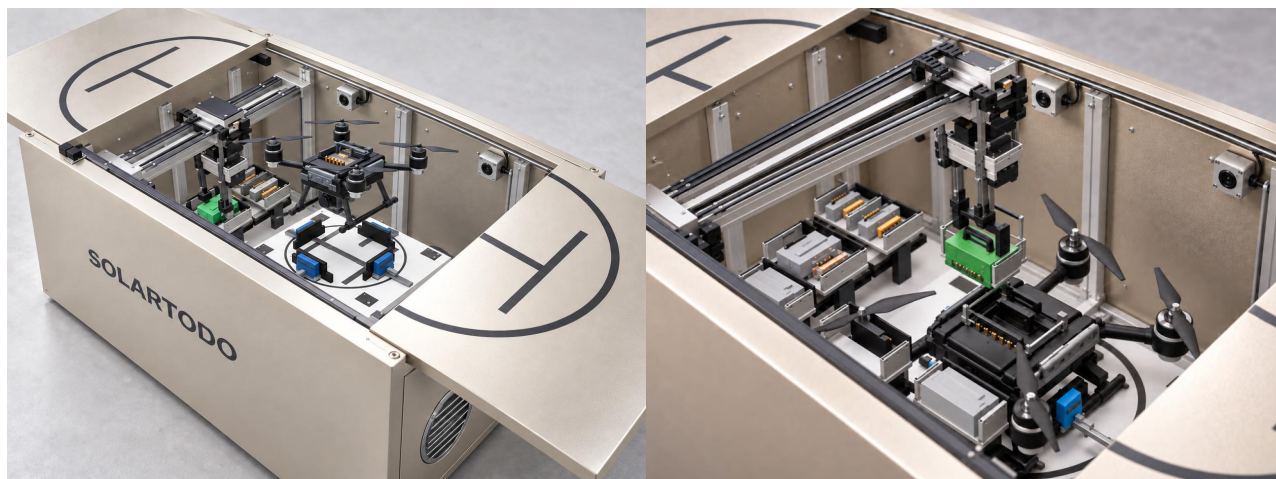
A1. STT 1S MAX Product Overview

STT 1S MAX is the four-rotor aerial unit supplied with the STT-HUB1101 battery exchange hangar. It provides daylight, low-light and thermal observation, laser distance measurement, position-aware recording and controlled recovery. Flight control, ground exchange and site task approval have separate status and safety paths.

54 min maximum forward flight	47 min maximum hover	149.9 Wh flight battery	15 m/s normal forward speed
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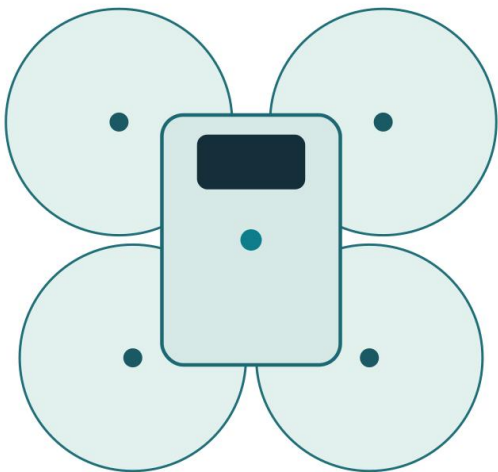
The 54-minute flight value uses constant 12 m/s forward flight in windless conditions, photo mode, obstacle action off and the full 100% to 0% battery window. The 47-minute hover value also uses the full battery window without wind. Mission duration is governed by route, payload operation, weather, battery health and the return reserve.

Customer function	Operating outcome
Aerial inspection	Wide, medium and tele imaging cover structures, boundaries and elevated assets.
Thermal observation	Radiometric images support hotspot and temperature review.
Distance and location	Laser ranging, satellite positioning and RTK support mapped observations.
Obstacle awareness	Omnidirectional vision and downward infrared sensing support flight-control decisions.
Battery exchange	The aircraft returns, confirms ground inhibit and receives an identified battery.
Event record	Aircraft, route, sensor, battery, alarm and operator data share one event timeline.



STT 1S MAX THREE VIEW

PLAN · PROP PLANE



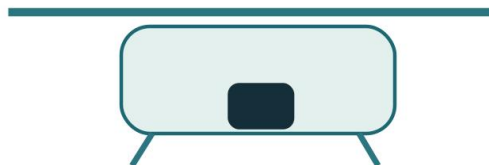
Body 377.7 × 416.2 mm; motor diagonal 498.5 mm

FRONT



Height 212.5 mm

SIDE



Battery 154 × 96 × 59 mm

A2. Complete Aircraft Technical Specification

Units and operating conditions are part of each value. Maximum flight time is not a guaranteed route duration. Maximum radio distance is not an approved operating radius.

A2.1 Airframe and flight performance

Parameter	STT 1S MAX	Unit	Operating condition
Aircraft configuration	Four-rotor multirotor		Integrated visual, thermal and ranging payload
Takeoff mass	1850	g	Battery, propellers and memory card installed
Maximum takeoff mass	2090	g	Total aircraft and fitted equipment
Body length without propellers	377.7	mm	Overall aircraft envelope
Body width without propellers	416.2	mm	Overall aircraft envelope
Body height without propellers	212.5	mm	Overall aircraft envelope
Diagonal motor wheelbase	498.5	mm	Motor-centre geometry
Front motor spacing	383.0	mm	Left to right
Rear motor spacing	343.0	mm	Left to right
Front to rear motor spacing	341.6	mm	Centre spacing
Propeller diameter	328	mm	Foldable low-noise propeller
Propeller pitch	163	mm	Installed propeller geometry
Maximum ascent speed, normal	6	m/s	Sea-level flight mode
Maximum ascent speed, sport	10	m/s	Sea-level flight mode
Maximum descent speed, normal	6	m/s	Sea-level flight mode
Maximum descent speed, sport	8	m/s	Sea-level flight mode
Maximum forward speed, normal	15	m/s	Obstacle sensing enabled; sea level, no wind

Parameter	STT 1S MAX	Unit	Operating condition
Maximum backward speed, normal	12	m/s	Obstacle sensing enabled; sea level, no wind
Maximum sideways speed, normal	10	m/s	Obstacle sensing enabled; sea level, no wind
Maximum forward speed, sport	21	m/s	Sea level, no wind
Maximum backward speed, sport	19	m/s	Sea level, no wind
Maximum sideways speed, sport	15	m/s	Sea level, no wind
Wind resistance in flight and at landing	12	m/s	Site flight policy may impose a lower limit
Maximum takeoff altitude	6500	m	Above mean sea level
Maximum forward-flight time	54	min	12 m/s, windless, photo mode, obstacle action off, 100% to 0% SOC
Maximum hover time	47	min	Windless, 100% to 0% SOC
Maximum operating radius	10	km	25 °C, windless, 15% landing reserve, approximately 15 m/s round trip and 18 min hover
Maximum flight distance	43	km	16 m/s, windless, 100% to 0% SOC
Maximum pitch angle, normal	25	deg	Flight-control mode limit
Maximum pitch angle, sport	30	deg	Flight-control mode limit
Maximum angular velocity	200	deg/s	Flight-control limit
Operating temperature	-20 to +50	°C	Aircraft operating range
Aircraft enclosure protection	IP55		Aircraft with fitted covers closed

A2.2 Flight battery and charging

Parameter	STT 1S MAX	Unit	Operating condition
Battery type	6S lithium-ion, NMC		Matched aircraft battery module
Battery capacity	6768	mAh	Nominal
Battery nominal voltage	22.14	V	Nominal
Battery maximum charging voltage	25.5	V	Battery-management limit
Battery energy	149.9	Wh	Nominal
Battery mass	640	g	Battery module
Battery length	154	mm	Module outside envelope
Battery width	96	mm	Module outside envelope
Battery height	59	mm	Module outside envelope
Battery cycle rating	400	cycles	Subject to battery-management limits
Battery discharge rating	4	C	Continuous rating
Battery maximum charge rate	1.8	C	Battery temperature and health permitting
Battery charging temperature	+5 to +45	°C	Battery-level operating range
Low-temperature charging	Battery self-heating supported		Enabled under battery-management control

A2.3 Visible-light imaging

Parameter	STT 1S MAX	Unit	Operating condition
Wide-angle camera	1/1.3-inch CMOS; 48 MP		82° field of view; 24 mm equivalent; f/1.7
Medium tele camera	1/1.3-inch CMOS; 48 MP		35° field of view; 70 mm equivalent; f/2.8
Tele camera	1/1.5-inch CMOS; 48 MP		15° field of view; 168 mm equivalent; f/2.8

Parameter	STT 1S MAX	Unit	Operating condition
Wide-angle focus	1 to infinity	m	Autofocus range
Medium/tele focus	3 to infinity	m	Autofocus range
Normal camera ISO	100 to 25,600		Wide, medium and tele cameras
Wide and medium night-scene ISO	100 to 409,600		Night-scene mode
Tele night-scene ISO	100 to 819,200		Night-scene mode
Electronic shutter	2 to 1/8000	s	Visible cameras
Wide maximum image	8064 × 6048	px	Still photograph
Medium maximum image	8064 × 6048	px	Still photograph
Tele maximum image	8192 × 6144	px	Still photograph
Visible-light video	3840 × 2160 at 30 fps		H.264/H.265; MP4
Minimum photo interval	0.7	s	Configured single-camera mode
Tele digital/hybrid zoom	16× / 112×		Digital / hybrid maximum
Visible photo format	JPEG		Wide, medium and tele cameras

A2.4 Thermal imaging and laser ranging

Parameter	STT 1S MAX	Unit	Operating condition
Thermal imager	Uncooled VOx microbolometer		Radiometric infrared payload
Native thermal resolution	640 × 512	px	12 μm pixel pitch; 30 Hz
Enhanced thermal image	1280 × 1024	px	Image enhancement mode; not native detector resolution
Thermal lens	45° diagonal; 53 mm equivalent; f/1.0		Focus 5 m to infinity
Thermal sensitivity	≤50	mK	At f/1.0

Parameter	STT 1S MAX	Unit	Operating condition
Infrared wavelength	8 to 14	μm	Long-wave infrared
Temperature range, high gain	-40 to +150	°C	Accuracy ± 2 °C or $\pm 2\%$, whichever is greater
Temperature range, low gain	0 to +500	°C	Accuracy ± 5 °C or $\pm 3\%$, whichever is greater
Temperature measurement	Spot and area		Radiometric images in 16-bit R-JPEG
Thermal digital zoom	28×		Maximum digital zoom
Laser range, normal incidence	1800	m	20% reflectivity target; 1 Hz
Laser range, oblique incidence	600	m	1:5 oblique-distance condition; 1 Hz
Laser blind zone	1	m	Minimum ranging distance
Laser distance accuracy	$\pm (0.2 + 0.0015D)$	m	D is distance in metres outside the 1 to 3 m near field
Near-infrared auxiliary light	5.7 ± 0.3	deg	Illumination field of view

A2.5 Gimbal, navigation and obstacle sensing

Parameter	STT 1S MAX	Unit	Operating condition
Gimbal stabilisation	Three-axis mechanical		Tilt, roll and pan
Gimbal mechanical tilt	-140 to +113	deg	Mechanical travel
Gimbal controlled tilt	-90 to +90	deg	Upper 70° to 90° may obstruct selected cameras
Gimbal mechanical roll	-52 to +52	deg	Mechanical travel
Gimbal mechanical pan	-65 to +65	deg	Mechanical travel
Gimbal tilt control speed	100	deg/s	Maximum
Gimbal angular vibration	± 0.005	deg	Stabilisation performance

Parameter	STT 1S MAX	Unit	Operating condition
Satellite positioning	GPS, BeiDou, Galileo, QZSS and GLONASS		QZSS and GLONASS require active RTK configuration
RTK module	Integrated		Aircraft positioning
Vision hover accuracy	± 0.1 vertical / ± 0.3 horizontal	m	Windless or breezy condition
GNSS hover accuracy	± 0.5 vertical / ± 0.5 horizontal	m	Windless or breezy condition
RTK hover accuracy	± 0.1 vertical / ± 0.1 horizontal	m	Windless or breezy condition
Obstacle sensing	Omnidirectional binocular vision with downward 3D infrared		Vision depends on surface texture and illumination
Forward obstacle detection	0.5 to 200	m	Measurement range 0.5 to 20 m; sensing speed at most 15 m/s
Backward obstacle measurement	0.5 to 20	m	Sensing speed at most 12 m/s
Lateral obstacle measurement	0.5 to 16	m	Sensing speed at most 10 m/s
Upward obstacle measurement	0.5 to 20	m	Sensing speed at most 6 m/s
Downward obstacle measurement	0.5 to 16	m	Sensing speed at most 6 m/s

A2.6 Communications, recording and control

Parameter	STT 1S MAX	Unit	Operating condition
Digital video-link bands	2.4, 5.2 and 5.8	GHz	Availability and radiated power depend on operating region
Maximum clear-path link distance, FCC	25	km	Unobstructed, free of interference; one-way radio limit
Maximum clear-path link distance, CE/SRRC/MIC	12	km	Unobstructed, free of interference; one-way radio limit

Parameter	STT 1S MAX	Unit	Operating condition
Live-view quality	Up to 1080p at 30 fps		Configured ground control link
Aircraft-to-ground video latency	Approximately 100	ms	Local radio path; network conditions add delay
Video codecs	H.264 and H.265		CBR/VBR; MP4
Visible-video bitrate	60 H.264 / 40 H.265	Mbps	Maximum encoding rates
Thermal-video bitrate	6.5 H.264 / 5 H.265	Mbps	640 × 512 at 30 fps
Removable media	microSD U3 / Class 10 / V30 or above		exFAT file system
Aircraft telemetry	Position, mode, battery, link, payload, alarms		Displayed with update age and event identity

STT 1S MAX SENSOR FIELDS

MULTI-SENSOR AIRCRAFT PAYLOAD

WIDE

48 MP

82° / 24 mm / f1.7

MEDIUM TELE

48 MP

35° / 70 mm / f2.8

TELE

48 MP

15° / 168 mm / f2.8

THERMAL

640 × 512

45° / 30 Hz / radiometric

LASER

1,800 m

normal-incidence maximum

Thermal enhancement produces 1280 × 1024 output; the detector remains 640 × 512.

A3. Mission Energy and Recovery

The aircraft carries a 6S, 6768 mAh, 149.9 Wh lithium-ion module. The battery-management system reports module identity, state of charge, state of health, temperature, voltage balance and charge eligibility. One battery is fitted to the aircraft; three matched modules are stored in STT-HUB1101 and one receiving bay remains free.

Energy and route item	STT 1S MAX operating value
Flight-ready threshold	At least 90% SOC, at least 80% SOH, correct module ID and no blocking alarm.
Return reserve	The active mission policy commands recovery at or before 20% SOC, or earlier when route, wind or battery condition requires it.
Energy from 90% to 20% SOC	104.93 Wh at nominal new-module energy.
Maximum forward flight	54 minutes under the full-battery condition in Section A1.
Maximum hover	47 minutes under the full-battery condition in Section A1.
Maximum operating radius	10 km at 25 °C without wind, with 15% landing reserve, approximately 15 m/s round-trip speed and 18 minutes hover.

The console derives mission energy from live aircraft telemetry, route distance, wind estimate and reserve policy. The operator sees remaining flight time, predicted landing SOC, distance to recovery, battery temperature and telemetry update age. A route is shortened or the aircraft returns when predicted landing SOC falls below the active limit.

STT 1S MAX ENERGY

FLIGHT BATTERY AND RETURN CONTROL

149.9 Wh

BATTERY ENERGY

54 min

FORWARD FLIGHT

47 min

HOVER

90%

RELEASE SOC

20%

RETURN LIMIT

104.93 Wh

90% TO 20% ENERGY

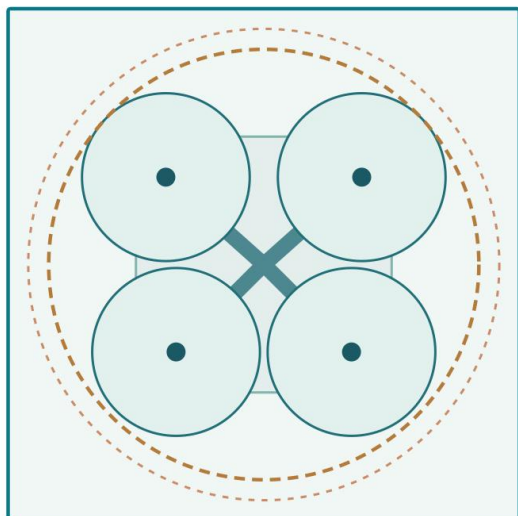
Mission console: live SOC · predicted landing SOC · time to recovery · battery identity and health

A4. Aircraft and Hangar Interface

STT-HUB1101 has a 1000 × 1000 mm roof aperture and 500 × 500 mm landing deck paired with STT 1S MAX. The 328 mm propellers and motor positions produce a 841.2 mm all-heading propeller-tip circle. Including ±40 mm landing-position allowance yields 921.2 mm controlled width and 39.4 mm nominal clearance per side within the aperture. Landing-gear retention, pitch and roll motion, transfer-tool path and fitted equipment are checked during site commissioning.

The 154 × 96 × 59 mm battery fits within a 180 × 120 × 80 mm receiving space for the module, guide, latch and fixed-contact interface. Ground exchange begins only after independent capture and propulsion-inhibit confirmation. It ends only after the new module is locked, identified and electrically checked and the transfer tool has retreated.

STT 1S MAX · LANDING INTERFACE

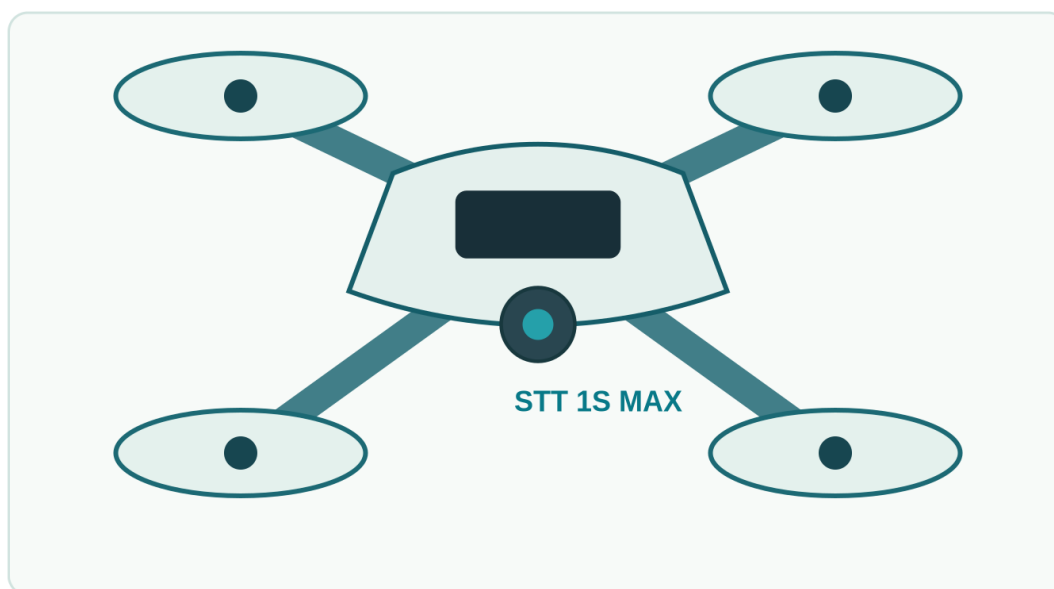


1000 × 1000 mm opening; 500 × 500 mm deck

Aircraft	STT 1S MAX
Motor diagonal	498.5 mm
Propeller diameter	328 mm
All-heading tip circle	841.2 mm
Landing allowance	±40 mm
Controlled width	921.2 mm
Clearance each side	39.4 mm

STT 1S MAX PRODUCT SKETCH

AIRCRAFT PRODUCT LINE SKETCH



Four-rotor outline · integrated visible / thermal / laser head · matched exchange battery

A5. Flight Modes and Console

Mode	Aircraft state	Operator action
PARKED	Aircraft secured, motors inhibited and battery identified.	Review aircraft and hangar readiness.
PREFLIGHT	Controller, sensors, route, weather, link, battery and permissions checked.	Resolve each blocking item.
READY	Flight checks and site approval complete.	Authorised operator releases the task.
MISSION	Route or supervised flight active.	Monitor position, sensing and landing SOC.
RETURNING	Aircraft follows the recovery route.	Verify landing zone and receiving bay.
APPROACH	Aircraft enters the controlled landing volume.	Keep personnel and robots clear.
SECURED	Touchdown, capture and propulsion inhibit confirmed.	Authorise ground exchange.
FLIGHT FAULT	Navigation, power, link or sensor condition blocks routine flight.	Follow the contingency procedure.

The aircraft card displays aircraft ID, flight mode, route and revision, location and position age, battery ID/ SOC/SOH, predicted landing SOC, controller and RTK status, link quality, visible and thermal payload state, alarms, hangar availability and approving operator. Commands progress through REQUESTED, ACCEPTED, IN PROGRESS, CONFIRMED or FAILED. A command acknowledgement is never displayed as physical completion.

A6. Operator Procedures

A6.1 Prepare and launch

1. Match the STT 1S MAX aircraft ID, battery ID and fitted payload to the site configuration.
2. Review route, weather, obstacle exposure, airspace permission, landing path and ground-robot exclusion zone.
3. Check battery eligibility, projected landing SOC, controller health, positioning, link and all observation sensors.
4. Confirm STT-HUB1101 recovery availability or assign an approved alternate landing area.
5. Record the approving operator and route revision; release only after aircraft and site controls both report ready.

6. Confirm actual takeoff from current aircraft telemetry.

A6.2 Observe and recover

Monitor route progress, visible and thermal views, obstacle sensing, battery trend, link, wind and predicted landing SOC. Preserve capture time, location confidence and sensor status with each observation. Trigger return when the controller or reserve policy requires it. Before approach, confirm the roof opening, deck, receiving bay and exclusion zone. The aircraft controller performs the landing; exchange follows independent capture and propulsion-inhibit confirmation.

A6.3 Prepare the next mission

Compare the installed module ID against the hangar ledger. Review battery lock, contacts, voltage, controller restart, positioning, sensors and link. Mechanical exchange does not arm the aircraft. A later flight needs its own approved route and release record.

A7. Alarms and Recovery

Alarm	Immediate response	Return-to-service condition
Flight controller	Hold launch or follow the active in-flight contingency.	Controller check and authorised release.
Energy / battery	Recover safely; block new launch on an invalid module.	Battery and ledger checks pass.
Navigation / RTK	Use aircraft failsafe or supervised pilot path.	Position and route checks pass.
Obstacle sensing	Reduce route exposure or return under controller policy.	Sensing health and area clear.
Command link	Do not infer a repeated command succeeded.	Fresh telemetry and command state.
Visible / thermal payload	Record reduced observation and end dependent task steps.	Sensor and storage checks pass.
Laser / gimbal	Stop distance-dependent measurements.	Alignment and range checks pass.
Approach / capture	Block battery transfer and apply recovery procedure.	Aircraft position and ground inhibit confirmed.

Alarm acknowledgement records awareness; it does not clear a physical fault. Damage, hard landing, battery swelling, contaminated contacts or failed propulsion inhibit stops automatic exchange until qualified inspection is complete.

A8. Inspection and Maintenance

Interval	Aircraft checks	Record
Before each flight	Frame, arms, propellers, landing gear, battery lock, contacts, cameras, infrared window, laser aperture and antennas.	Aircraft ID, battery ID and release result.
After recovery	Impact marks, propellers, battery temperature, contacts, landing alignment and exchange event.	Landing SOC, module movement and alarms.
Weekly	Controller events, link, positioning, gimbal, optics, contacts and latches.	Repeated fault trend and assigned action.
After battery or payload change	Takeoff mass, centre of gravity, attachment, route configuration and preflight checks.	Configuration revision and authorised release.
After incident	Structure, propulsion, battery, payload alignment, controller log and hangar interface.	Inspection, correction and return-to-service approval.

Clean and service the aircraft with propulsion inhibited, battery isolated and airframe secured. Battery, propeller or payload changes require an updated aircraft configuration and STT-HUB1101 compatibility record.

PART III

STT-HUB1101 Battery Exchange Hangar

Four-position inventory, supervised battery exchange and aircraft turnaround.



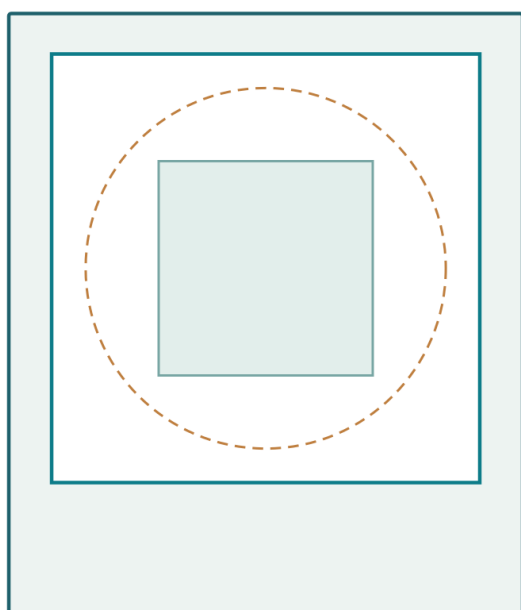
Closed-cabinet exterior view.

STT-HUB1101 Customer Outline and Aircraft Interface

The combined plan relates cabinet footprint, roof travel, aperture, landing deck, rotor sweep and battery receiving position. Use it with the site configuration record when allocating clearances and the aircraft recovery zone.

STT HUB1101 CUSTOMER OUTLINE

PLAN · STT-HUB1101



Four battery bays; one free receiving position

Cabinet body	1200 × 1400 × 1000 mm
Roof aperture	1000 × 1000 mm
Landing deck	500 × 500 mm
Aircraft	STT 1S MAX
Battery	149.9 Wh
Closed enclosure	IP65

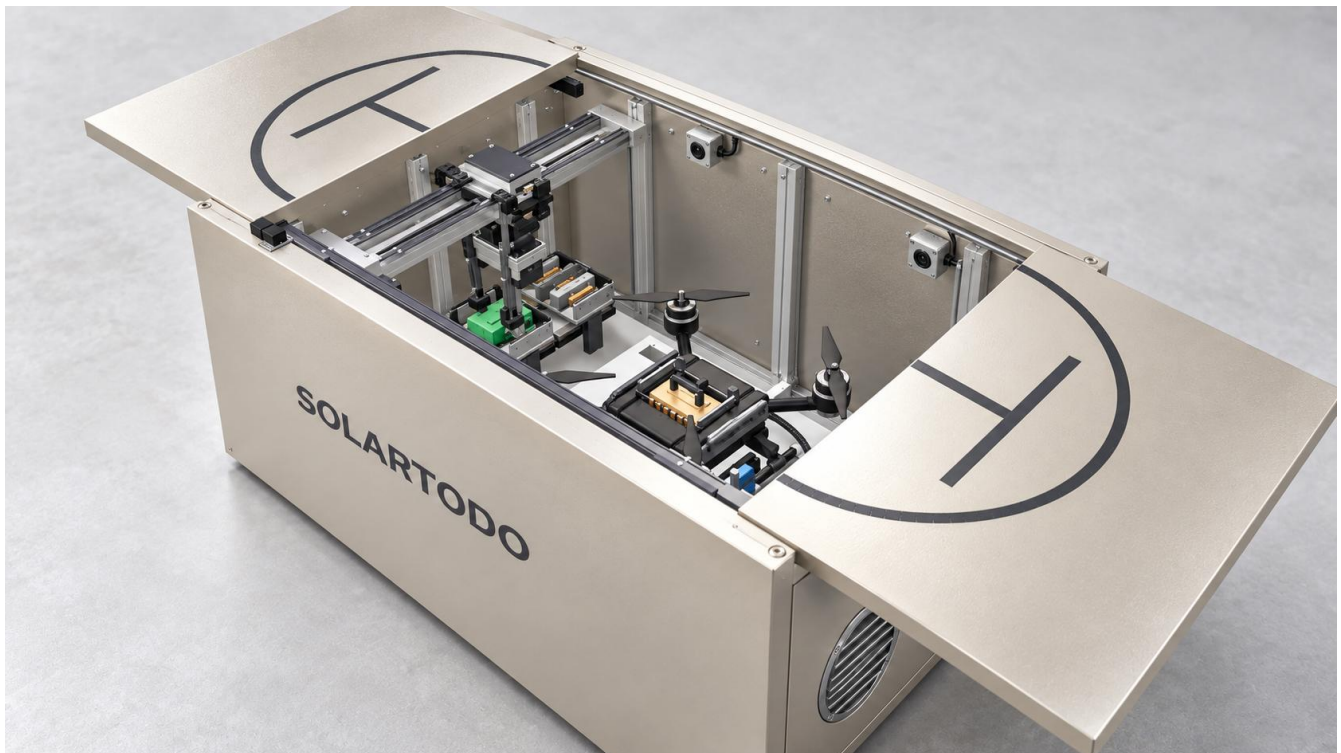
Nominal dimensions in millimetres. Keep the roof-open width, maintenance access and flight approach clear in the installed site plan.

Applicability. This manual covers model STT-HUB1101 in the four-bay independent hangar configuration paired with STT 1S MAX and its matched battery module. The product identification plate and configured aircraft/battery record identify the equipment to which each operating procedure applies.

1. Product Overview

1.1 Purpose

STT-HUB1101 receives the STT 1S MAX multirotor aircraft, secures it on an elevating landing deck, exchanges its removable battery module, records battery location and charge status, and hands the aircraft back to the flight controller for the next mission. The exchange sequence is supervised by the local hangar controller. The operator can monitor status at the local console and, where enabled, through the remote dashboard.

**4**

battery storage bays

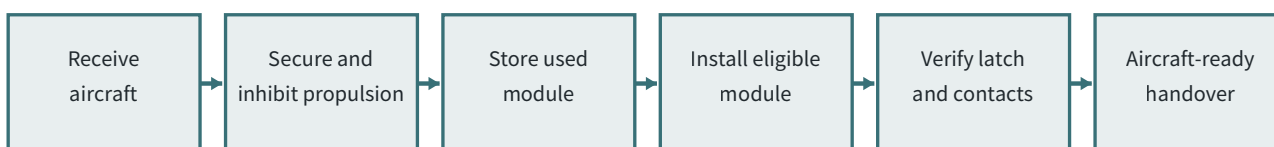
150 smaximum exchange cycle under
stated conditions**IP65**closed enclosure ingress
protection

1.2 What the product does

Function	Customer outcome
Aircraft reception	Opens the roof, presents the landing deck and establishes aircraft position before handling begins.
Battery exchange	Removes the returned module, places it in the reserved bay, installs an eligible module and confirms mechanical and electrical engagement.
Energy management	Tracks battery identity, state of charge, temperature, charging permission and bay occupancy.
Mission turnaround	Releases the aircraft only after the transfer tool is clear and the independent flight and site permissions are satisfied.
Local supervision	Shows equipment state, battery inventory, camera views, alarms and event history.
Fault containment	Stops progression when identity, position, latch, power or safety feedback is inconsistent.

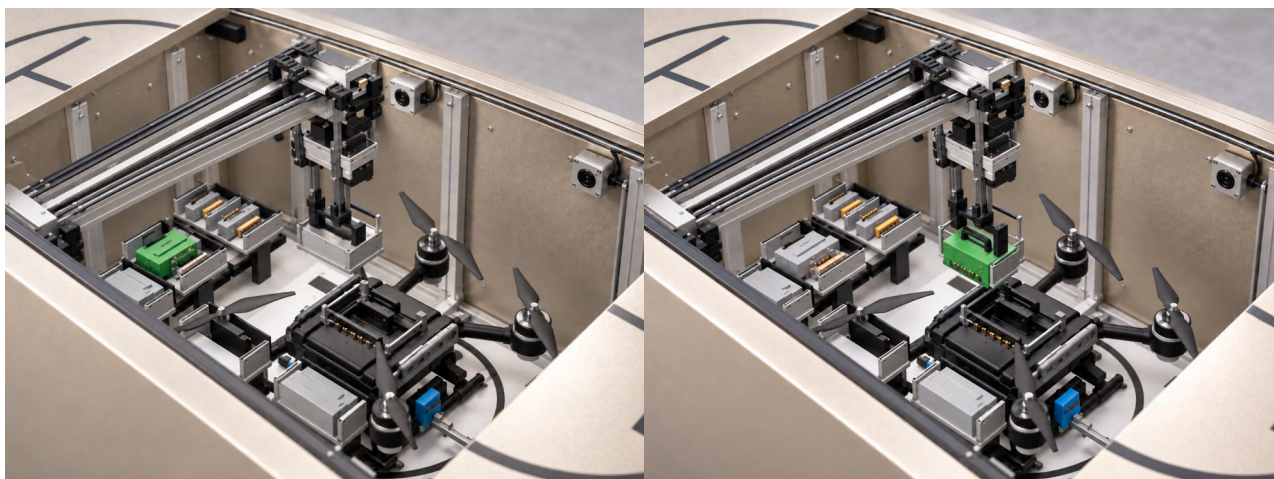
1.3 The mission cycle

One complete turnaround



At every transition: confirm physical feedback, identity and safety permission before the next action.

The exchange clock starts when aircraft touchdown is detected at the landing deck. It ends when E10 confirms the deck at release height, the transfer tool clear, the battery inventory reconciled and **AIRCRAFT READY**. Capture and ground propulsion inhibit are included. The later operator **Handover** request, aircraft preflight checks, flight authorization and departure are outside this clock.



1.4 Battery inventory rule

The standard deployment carries 4 matched battery modules: one installed on the aircraft and 3 in the hangar. One of the 4 storage bays remains empty before a return so it can receive the used module. Every module has a unique identity and a single recorded location: aircraft, transfer tool or bay.

Four-bay battery inventory

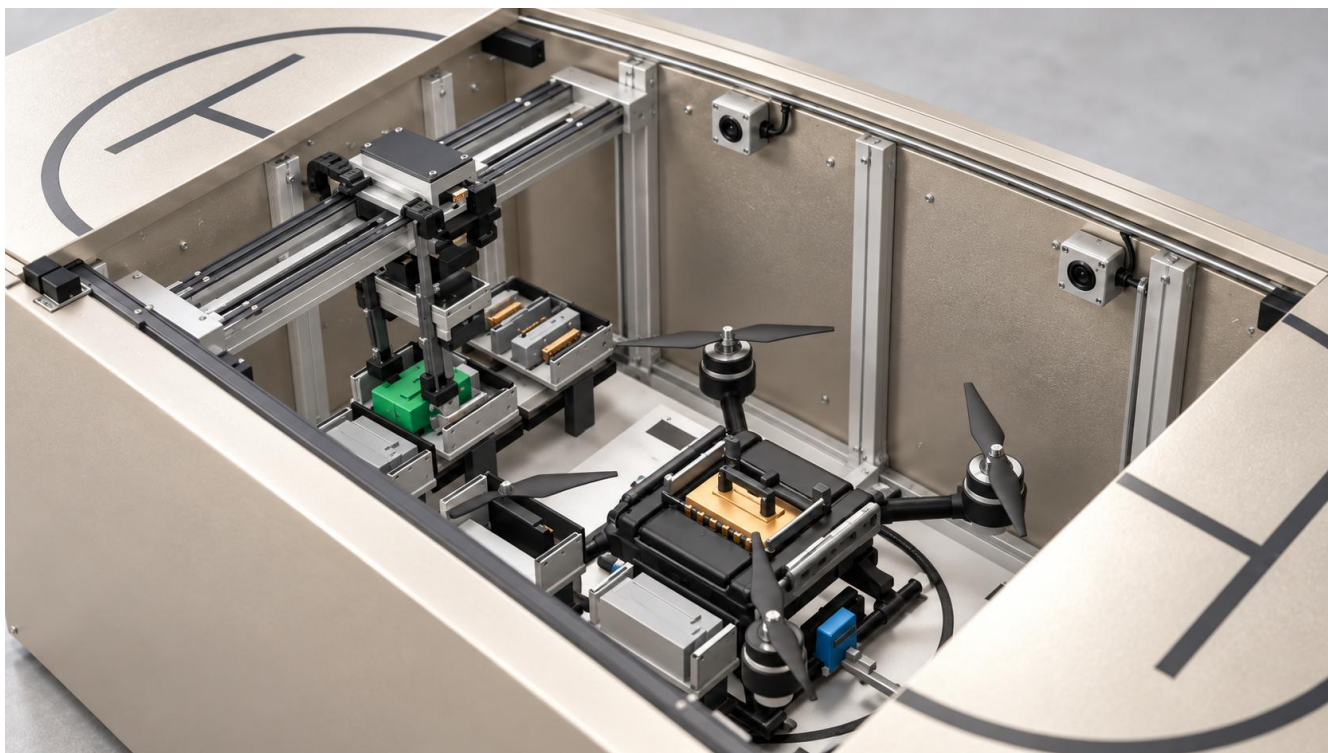


The empty bay receives the returning aircraft's used pack before a replacement pack leaves storage.

2. System Functions

2.1 Product zones

The sealed enclosure contains a roof opening, an elevating landing deck, an aircraft retention zone, a battery transfer zone and four battery bays. The local control system coordinates motion and inventory. A separate safety control path governs access and emergency stopping. Two internal cameras provide live observation of landing and battery transfer.



Zone	Function	Handover condition
Sliding roof	Clears the landing aperture and closes the enclosure between flights.	Both roof leaves report the commanded position.
Landing deck	Presents the aircraft at reception height and moves it to the exchange position.	Deck position and aircraft retention agree.
Transfer mechanism	Grips and transfers one battery module at a time.	Tool position and held-module identity are known.
Battery bays	Store, identify and charge compatible modules.	A bay may supply a module only when its eligibility checks pass.
Observation views	Show the landing zone and transfer zone to authorized users.	Video is an observation source; motion and safety use independent feedback.

2.2 Operating states

State	Meaning	Permitted operator action
STANDBY	Power available; no mission is active.	Review status, start self-check or request shutdown.
READY	Self-check passed and the receiving path is available.	Authorize a return mission.

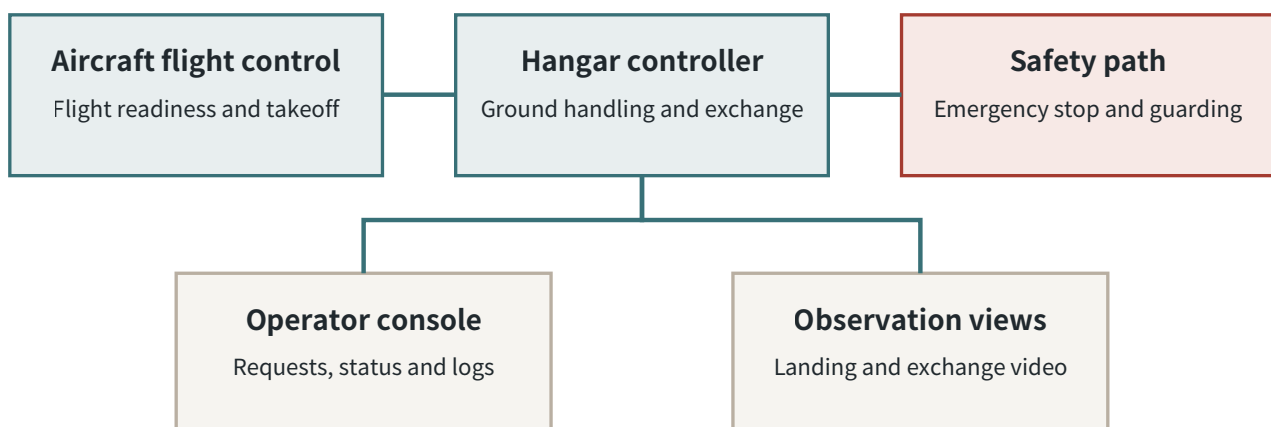
State	Meaning	Permitted operator action
RECOVERY	Roof and deck are preparing for the inbound aircraft.	Observe arrival; request a controlled abort if required.
AIRCRAFT SECURED	Landing, capture and propulsion inhibit are confirmed.	Authorize the exchange sequence.
EXCHANGE	The controller manages the used and fresh modules.	Monitor progress; do not enter the enclosure.
AIRCRAFT READY	Exchange is complete; transfer tool and deck are clear.	Review flight-controller and site permission before takeoff.
FAULT	A required feedback or safety condition failed.	Follow the alarm-specific recovery card.
SERVICE	Authorized inspection and controlled individual movements.	Qualified personnel only, with interlocks active.

Charging state is tracked per battery bay and may continue while the hangar is in STANDBY or READY.

2.3 Product boundaries

The hangar controls ground handling. The aircraft flight controller controls flight. The local console presents status and submits requests; it does not replace the hangar's safety circuit. A remote command cannot override local access protection, an emergency stop or the aircraft's own flight checks. Camera images support observation and event review, while physical position, latch and safety decisions use their corresponding feedback channels.

Independent control and permission paths



Operator and camera data do not replace physical safety feedback

2.4 Internal observation

Two 4 MP internal cameras provide separate views of the aircraft landing area and battery transfer area. The Cameras page shows each stream, its connection state and the time of its latest frame. Loss of either stream raises A701 and is recorded with the active mission. Video is available to authorized operators for live supervision and incident review.



The left image identifies the landing-zone observation position; the right identifies the transfer-zone position. Camera access and footage export follow the customer's role and retention policy.

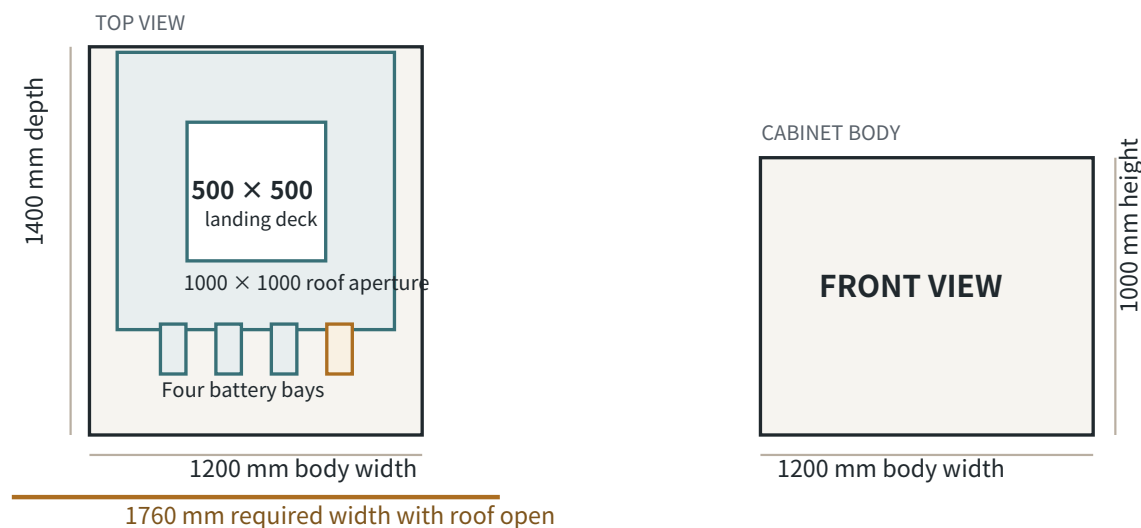
3. Technical Specification

3.1 Mechanical and physical data

Parameter	STT-HUB1101 specification
Cabinet body, W × D × H	1200 × 1400 × 1000 mm
Width required with roof fully open	1760 mm
Clear roof aperture	1000 × 1000 mm
Landing deck	500 × 500 mm
Landing alignment allowance	±40 mm at the deck reference
Battery storage bays	4
Matched battery modules in standard system	4 total: 3 stored and one on aircraft
Reserved reception bay	1 before aircraft return
Cabinet mass	Approximately 145 kg, excluding aircraft and battery modules
Roof	Two independently monitored sliding leaves

Parameter	STT-HUB1101 specification
Aircraft platform	Elevating deck with aircraft retention and position feedback

Product layout and operating width



Installation planning must include roof travel, maintenance access, cable routing and the aircraft approach volume in addition to the cabinet body dimensions.

3.2 Battery and energy data

Parameter	STT-HUB1101 specification
Module interface	Guided, keyed and mechanically locked fixed-contact battery interface
Hangar battery-interface clearance envelope	180 × 120 × 80 mm; maximum allocated space for the matched module and interface, not a statement of the module's measured outside dimensions
Cell arrangement	6S rechargeable lithium battery
Nominal voltage	22.14 V
Nominal capacity	6.768 Ah
Nominal energy	149.9 Wh
Module mass and outside envelope	640 g; 154 × 96 × 59 mm
Battery cycle rating	400 cycles

Parameter	STT-HUB1101 specification
Continuous cell discharge rating	4C
Fast-charge rating	Up to 1.8C when battery temperature and health permit
Minimum state of charge for flight eligibility	90%
Minimum battery state of health for flight eligibility	80%
Maximum resting cell-voltage spread for eligibility	30 mV
Independent charging channels	3
Maximum channel charge current	12.18 A
Maximum channel output	800 W
Charge time	Up to 25 minutes from 20% to 90% state of charge at 25 °C

Each battery module is accepted only when its identity, temperature, voltage, cell balance, health and lock status are valid. An empty bay cannot be energized for charging. Charging stops and reports a fault if the battery or bay feedback falls outside the permitted range.

The module record identifies its outside dimensions, fixed-contact and latch revision, BMS limits and charge profile. The 4C discharge and up-to-1.8C charging limits apply only when module health and temperature permit them. The controller limits actual charging current to the lower of the module limit and the available channel output.

3.3 Electrical, environmental and service data

Parameter	STT-HUB1101 specification
AC supply	220–240 V AC, 50/60 Hz, 16 A circuit
Maximum input power	3.2 kW
Exchange cycle	No more than 150 seconds from landing-deck touchdown detection through E10 AIRCRAFT READY , including capture and ground propulsion inhibit, with an eligible battery available
Enclosure ingress protection	IP65 with roof closed
Hangar operating temperature	–20 to +50 °C
Battery charging temperature	+5 to +40 °C
Relative humidity	5–95% RH, non-condensing

Parameter	STT-HUB1101 specification
Local console	10.1-inch industrial touchscreen
Network	Gigabit Ethernet; optional cellular backhaul
Internal observation	2 independent views: landing zone and transfer zone
Local event history	90 days
Emergency-stop and access-interlock design basis	PL e / Category 4, ISO 13849-1:2023
Electrical design standard	IEC 60204-1
Enclosure classification standard	IEC 60529

The ingress rating applies to the closed enclosure. A return, takeoff or open-roof exchange is suspended when precipitation, wind or other site conditions make aircraft recovery unsafe. Battery charging is conditioned separately from the hangar operating range.

3.4 Exchange-time definition

The published exchange time starts at landing-deck touchdown detection and includes E01 aircraft capture, E02 ground propulsion inhibit, E03–E10 deck travel, module transfer, latch/contact and inventory verification, tool retreat and deck return to **AIRCRAFT READY**. Roof and deck preparation before touchdown, the later operator **Handover** request, departure, remote flight authorization and aircraft-specific preflight or boot checks are outside this interval.

4. Battery and Charging Management

4.1 Module identification

The system maintains a record for each battery module: module ID, bay or aircraft location, state of charge, temperature, cycle count, health status, charge permission, last exchange and active alarm. A module with an unknown or duplicate identity is not selected for flight.

4.2 Eligibility to fly

A module becomes eligible only after the controller confirms its identity, charge level, temperature, health, contact status and mechanical fit. The operator sees eligibility as a distinct state. “Charge completed” alone does not grant flight eligibility.

Eligibility check	Flight release rule
Identity	The module ID matches the configured aircraft and one physical location.

Eligibility check	Flight release rule
State of charge	At least 90%.
State of health	At least 80%.
Cell balance	Resting cell-voltage spread no greater than 30 mV.
Temperature	Within the battery's approved flight range; fast charging within +5 to +40 °C.
Interface	Correct module orientation, locked latch and stable electrical feedback.
Fault history	No active battery, bay or charging fault.

4.3 Charging sequence

1. The returned module is deposited in the reserved bay and the tool is clear.
2. The bay confirms module presence, identity, connector engagement and temperature.
3. The charging controller requests battery permission and starts a monitored charge profile.
4. Current, voltage, cell balance and temperature remain under continuous supervision.
5. The channel transitions to complete, hold or fault according to battery feedback.
6. The module is released for flight only after all eligibility checks pass.

Battery handling. Do not force a module into a bay or aircraft receptacle. Do not use a module with visible damage, swelling, liquid ingress, damaged contacts or an identity mismatch. Isolate the affected module and follow the site battery incident procedure.

4.4 Capacity and turnaround

The four-module system has one aircraft-installed module and up to three stored modules. The reserved empty bay receives the module removed from a returning aircraft. Sustainable flight cadence depends on battery charge recovery, aircraft mission duration and the number of modules that pass eligibility checks; it is not determined by exchange time alone.

5. Safety Architecture and Control Interface

5.1 Safety functions

Emergency-stop and access-interlock functions use a PL e / Category 4 design basis under ISO 13849-1:2023. They use monitored inputs and a safety control path independent of the operator display. The controller requires physical confirmation for aircraft retention, ground propulsion inhibit, roof position, deck position, battery latch, transfer-tool clearance and power-state changes. The unit configuration record identifies the installed safety-function revisions and their acceptance results.

Safety condition	Required response
Emergency stop actuated	Stop hazardous hangar motion; report actual stopping and retained-load status.
Access opened during motion	Inhibit new motion and execute the defined safe stop.
Aircraft not secured	Prevent deck descent and battery removal.
Ground propulsion inhibit absent	Prevent access to the aircraft battery and prevent exchange.
Battery location unknown	Lock the exchange sequence and request authorized inspection.
Charge-stop feedback absent	Prevent unplugging or transfer of the affected module.
Communication or controller restart	Re-read physical position and battery identity before accepting a new request.

After the aircraft has left the hangar, a hangar emergency stop or communication loss does not issue an unconditional in-flight propulsion power cut. Aircraft flight protection remains with its flight controller.

5.2 Operator console

The local console has six primary pages. The current page and mode are always visible in the header.

Page	Information and control
Home	Current system state, active mission, aircraft identity, roof/deck status and highest-priority alarm.
Mission	Recovery, exchange and handover timeline; Start Return, Pause, Controlled Abort and Handover requests.

Page	Information and control
Batteries	Aircraft and bay inventory, state of charge, temperature, health, charging and flight eligibility.
Cameras	Independent landing-zone and transfer-zone live views with connection timestamps.
Alarms	Active alarm, cause, affected zone, permitted action, acknowledgement and event history.
Service	Authorized diagnostics, individual motion requests and inspection records.

The display distinguishes “request received” , “request accepted” , “action in progress” , “physical completion confirmed” and “failed” . Acknowledging an alarm does not clear the underlying condition or grant motion permission.

STT-HUB1101
System: READY

Home
Mission
Batteries
Cameras
Alarms
Service

Mission overview
Roof: CLOSED Deck: PARKED
Tool: CLEAR Safety: HEALTHY

Aircraft
ID: UAV-01
Location: IN FLIGHT

Battery inventory

BAY 1
ELIGIBLE

BAY 2
CHARGING

BAY 3
ELIGIBLE

BAY 4
RESERVED

START RETURN
No active alarms

The Home page places operating state and blocking alarms above routine details. Battery inventory displays the reserved bay separately from eligible and charging modules. A mission request is presented only when the controller reports the required preconditions; the button itself is never proof of an action's physical completion.

5.3 Roles and permissions

Role	Permissions
Operator	Monitor, run daily checks, authorize standard missions, acknowledge alarms and record handover.
Supervisor	Review alarms, authorize a controlled restart after a resolved operating fault and export records.
Service technician	Enter service mode after site isolation, inspect the mechanism and perform controlled recovery.
Administrator	Manage users, network policy, log retention and approved configuration records.

Remote users may request a mission or review permitted data. Local safety conditions, aircraft flight checks and on-site permissions remain authoritative.

6. Installation and Operating Conditions

6.1 Site preparation

Select a level, stable location with an unobstructed approach and departure path. Reserve the 1760 mm roof-open width, access for maintenance, space for the separate electrical connection, and a controlled personnel exclusion zone around moving equipment. Provide a 220–240 V AC supply on a 16 A circuit with protective earth and the site's specified surge and isolation arrangements. Connect the local network before remote functions are enabled.

6.2 Environmental use

Operate the closed enclosure within –20 to +50 °C. The battery conditioning system permits charging only in its +5 to +40 °C battery-temperature band. Keep roof opening, aircraft recovery and takeoff within the aircraft's permitted weather and local flight conditions. Inspect roof seals, drainage and air paths after severe weather or contamination.

6.3 Aircraft and module compatibility

Use only an aircraft and battery module assigned to the STT-HUB1101 configuration record. Verify that the aircraft's landing geometry, retention points, battery receptacle, center of gravity and flight-controller handover interface match the installed hangar configuration. A change of aircraft, battery module or software revision requires the corresponding configuration record and functional check before routine operation.

6.4 Identification and handover

At customer handover, record the hangar serial number, aircraft identity, four module IDs, software version, safety configuration, network settings, site contact and operator training completion. Keep that record with this manual and the site service log.

7. Operator Procedures

7.1 Before each shift

01 Confirm site conditions

Check the approach area, exclusion zone, weather, power, network and roof clearance. Do not start a return mission with personnel or loose objects in the controlled area.

02 Confirm equipment identity

Read the hangar, aircraft and battery IDs on Home and Batteries. Check that the configured aircraft and all installed modules match the site record.

03 Confirm inventory

Verify one free receiving bay and at least one flight-eligible replacement module. Isolate any damaged, unidentified or alarmed module.

04 Confirm readiness

Check that the safety circuit is healthy, roof and deck feedback are current, the transfer tool is clear and no blocking alarm is active. Record the shift check.

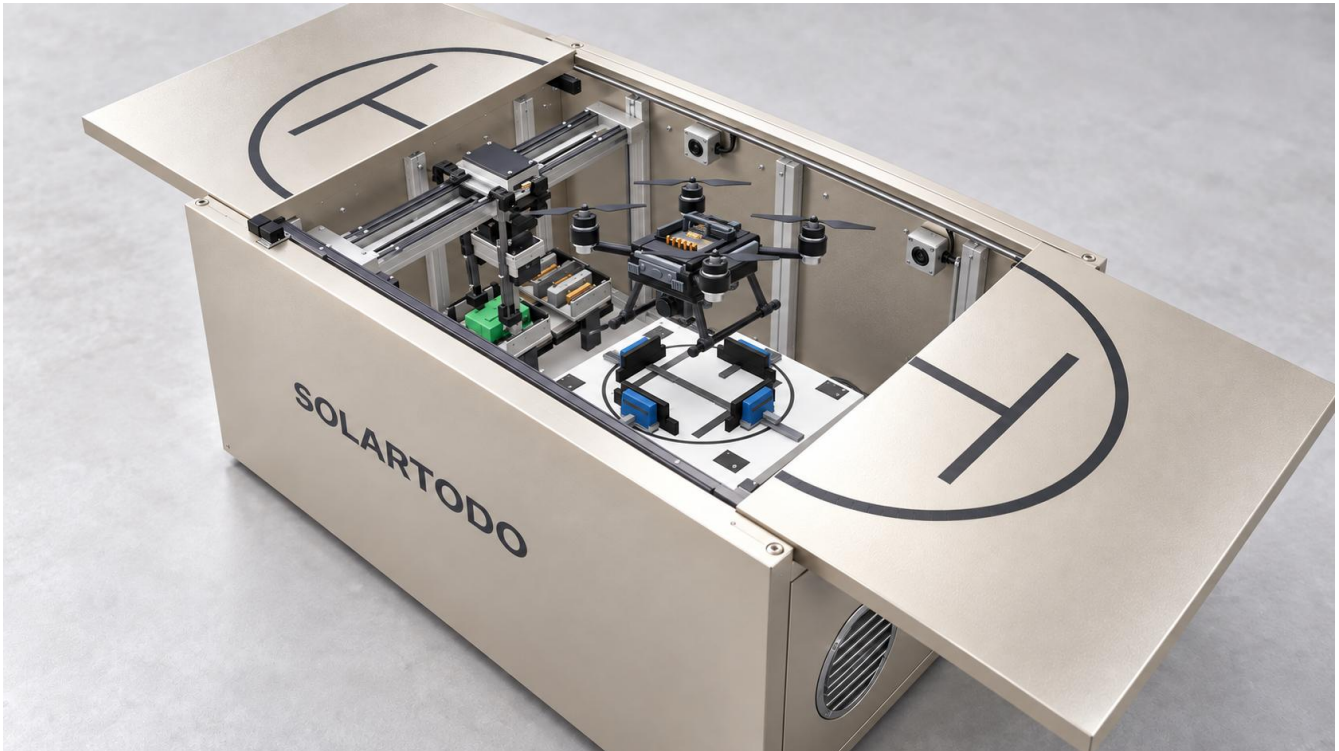
7.2 Start and self-check

1. Apply site power using the installed supply isolator. Wait for the local console to identify STT-HUB1101 and display its configuration.
2. Select **Home** → **Run Self-Check**. Observe roof, deck, tool, bay, safety and communication results.
3. Confirm that Home displays **READY**. If any item fails, leave the unit in **FAULT** and use the alarm table; do not repeatedly request a start.

7.3 Receive an aircraft

1. On **Mission**, select **Start Return** only when the aircraft and site are cleared for return.
2. Confirm the roof reaches its open feedback state and the deck reaches reception height.

3. Watch the aircraft arrive using direct site observation and the landing-zone view. Video supplements, but does not replace, the landing and retention indicators.
4. Wait for **AIRCRAFT SECURED**. Verify the displayed aircraft ID, capture status and ground propulsion inhibit feedback.
5. If capture or propulsion inhibit does not confirm, select **Controlled Abort** and follow the displayed alarm instruction. Do not authorize exchange.



7.4 Exchange a battery

1. In **AIRCRAFT SECURED**, review the eligible replacement module and reserved receiving bay shown on **Batteries**.
2. On **Mission**, select **Start Exchange**. The controller lowers the secured aircraft to the exchange position.
3. Observe the old module release, transfer-tool grip and transfer into the receiving bay. The module ID must move from aircraft to tool to bay exactly once.
4. Observe selection of the eligible new module, transfer to the aircraft, mechanical latch confirmation and electrical connection confirmation.
5. Verify tool-clear status and deck return. The process is complete only when **AIRCRAFT READY** appears and the inventory ledger shows the new module on the aircraft.
6. Any interrupted grip, conflicting ID, latch failure or charge-stop failure moves the hangar to **FAULT**. Stop at the displayed fault stage; do not initiate a second exchange.

7.5 Hand the aircraft back for flight

1. Confirm **AIRCRAFT READY** and verify roof, deck, retention release and tool-clear feedback on **Mission**.
2. Confirm the aircraft flight controller reports its own flight-ready condition.

3. Clear personnel from the controlled area and obtain the site flight authorization.
4. Select **Handover**. Flight authorization is completed by the aircraft and site flight-control procedure; the hangar does not unilaterally command takeoff.

7.6 Normal stop

1. Do not begin shutdown while an aircraft is inbound or a module is held by the transfer tool.
2. On **Mission**, request **Controlled Stop**. Wait for the controller to finish or reach its safe stopping point.
3. Confirm the aircraft and every module have a known location, the roof is closed, the tool is parked and charging channels show their final state.
4. Export or hand over the event log as required by the site procedure, then use the supply isolator if the hangar is to be powered down.

7.7 Emergency stop

Actuate the nearest emergency-stop control when immediate hazardous motion must stop. Keep personnel clear of the roof, deck, tool and suspended modules. The operator reports the incident and records the indicated alarm. Only authorized service personnel may inspect retained loads and residual energy before reset. A reset restores permission to run self-check; it does not resume an interrupted exchange.

7.8 Pause, controlled abort and emergency stop

Control	Use	What happens next
Pause	A nonhazardous operational hold is required.	The controller stops at the next defined hold point; current battery and aircraft locations remain visible.
Controlled Abort	A mission should end without immediate safety danger.	The controller follows the state-specific abort path and reports the resulting physical state.
Emergency Stop	Immediate hazardous motion must stop.	The independent safety path acts; authorized inspection is required before a new self-check.

Do not use Pause as an emergency-stop control. Do not use Emergency Stop as a routine shutdown method. After any interrupted battery transfer, the operator must confirm where the module is before any subsequent request.

7.9 Battery quarantine

1. Select the affected module on **Batteries** and read its identity, last location, temperature and alarm history.

2. If the module is still in the aircraft or transfer tool, stop routine operation and assign the condition to a service technician. Do not command another transfer.
3. If the module is secure in a bay, select **Mark Unavailable**. Confirm that it is excluded from automatic flight selection and fast charging.
4. Apply the site's physical identification and isolation process without opening the enclosure while hazardous motion is enabled.
5. Record the reason, module ID, operator and final disposition. A service technician must complete the inspection before eligibility can be restored.

7.10 Network loss or controller restart

The local hangar continues to enforce its physical and safety interlocks without a remote connection. The remote dashboard marks the last received status as stale. After reconnection or controller restart, compare the displayed aircraft, module and mechanism positions with the locally confirmed state. Do not resend the last request automatically. A supervisor authorizes a new self-check after the location ledger is reconciled.

7.11 Off-center or incomplete landing

If the aircraft lands outside the permitted alignment window, retention is not confirmed, or the deck reports conflicting position feedback, the controller must not lower the aircraft. The operator keeps the area clear, reviews A201/A102 and follows the aircraft recovery procedure for the site. No battery exchange is permitted until the aircraft is secured and ground propulsion inhibit is confirmed.

8. Alarms and Recovery

8.1 Alarm priority

Priority	Meaning	Operator response
STOP	Safety or physical-state conflict.	Keep the area clear, stop new requests and call qualified service staff.
ACTION	Mission cannot continue until a defined condition is resolved.	Follow the alarm card and request a new self-check afterward.
ADVISORY	Service or observation is degraded without immediate hazardous motion.	Record and plan service; the console states whether missions remain permitted.

8.2 Alarm reference

Code	Condition	Immediate operator action	Recovery owner
A101	Roof position mismatch or obstruction	Stop roof requests; keep clear of travel.	Service technician
A102	Deck position mismatch	Do not permit aircraft exchange or access below deck.	Service technician
A201	Aircraft capture not confirmed	Do not lower deck or exchange battery.	Operator, then service if persistent
A202	Ground propulsion inhibit not confirmed	Do not unlock or touch aircraft battery.	Service technician
A301	Battery identity or location mismatch	Do not repeat transfer; preserve current position ledger.	Service technician
A302	No receiving bay or no eligible module	Do not start exchange; restore inventory.	Operator
A303	Battery mechanical latch or electrical contact mismatch	Do not hand aircraft to flight control.	Service technician
A401	Battery temperature or health outside charge range	Isolate affected module from service.	Service technician
A402	Charge stop not confirmed	Do not disconnect or transfer affected module.	Service technician
A501	Emergency stop or access safety circuit open	Keep clear; identify the cause before reset.	Supervisor and service technician
A601	Controller or network communication lost	Do not repeat the previous request after reconnection.	Supervisor
A701	Landing-zone or transfer-zone video unavailable	Use the site observation procedure; record the degraded view.	Operator / service technician

8.3 Recovery rules

1. Record the alarm code, time, stage, aircraft ID, battery ID and last confirmed position.
2. Determine whether a module is on the aircraft, in a bay or held by the tool. Treat an unknown position as a STOP condition.

3. Determine whether the roof, deck or tool can move and whether stored electrical or gravitational energy remains.
4. Service personnel isolate the affected area and resolve the physical cause. Do not force a module, defeat a guard or clear a record to make the display appear ready.
5. After repair, repeat the affected functional check and then the system self-check. A supervisor records the return to service.

8.4 Detailed recovery cards

A202 — Ground propulsion inhibit missing

Visible condition: AIRCRAFT SECURED is withheld or the exchange remains blocked. **Do now:** keep personnel clear of the aircraft and do not unlock its battery. **Service check:** confirm the aircraft identity, independent inhibit channel, actual propulsion-disable feedback and the aircraft's own armed state. **Return:** repeat the inhibit and aircraft retention check before accepting another exchange request.

A303 — Battery latch or contact mismatch

Visible condition: the new module is present, but mechanical lock and electrical contact do not agree. **Do now:** prevent aircraft handover and record the module ID. **Service check:** isolate hazardous energy, inspect the module position and contact surfaces, and check the latch without forcing the module. **Return:** verify both lock and contact independently, then repeat the full aircraft-ready check.

A402 — Charge stop not confirmed

Visible condition: the charging channel has received a stop request but no confirmed stop feedback. **Do now:** do not transfer or disconnect the module. **Service check:** check actual current, channel state, module temperature and electrical isolation. **Return:** prove current has stopped, reconcile module identity and repeat the channel functional check.

A501 — Safety path open

Visible condition: hazardous hangar motion is inhibited. **Do now:** leave the area clear and do not bridge the access switch or emergency-stop circuit. **Service check:** identify the actuated device, confirm retained loads and remaining energy, resolve the cause, then perform the prescribed safety-function check. **Return:** reset the safety path, run self-check and obtain supervisor authorization.

A601 — Communication loss

Visible condition: the console or remote dashboard reports a lost controller session. **Do now:** preserve the last request ID and do not repeat the motion request. **Service check:** compare the current physical positions, controller session and battery ledger. **Return:** after state reconciliation, run self-check and submit a new request with a new ID.

9. Inspection and Maintenance

9.1 Routine inspections

Interval	Check	Acceptance condition
Each shift	Area clearance, roof tracks, deck, bay occupancy, battery exterior, alarms	Clean, unobstructed and consistent with console record
Weekly	Camera lenses, seals, drainage, cable protection, contacts and charging status	No contamination, wear, damage or abnormal heating
Monthly	Roof/deck/tool motion history, latch feedback, event log capacity, network backup	No recurrent alarm or unexplained state change
After any intervention	Affected safety, motion, battery and flight handover checks	Recorded pass before service resumes

9.2 Service mode

Service mode is restricted to authorized personnel. Stop the active mission, identify the aircraft and all battery locations, isolate the relevant energy sources and secure any elevated or held load before entering the enclosure. Individual movements remain under interlock control and require a clear route. Return to READY only after the repaired function, independent safety feedback and full self-check are verified.

9.3 Cleaning and storage

Keep the landing deck, roof seals, battery contacts and camera windows free of debris. Use cleaning methods compatible with the installed materials and disconnect energy where access is required. Do not spray liquid into an open enclosure or onto battery contacts. For extended storage, remove the aircraft and batteries according to the site battery policy, close the roof and record the shutdown condition.

10. Records and Handover

10.1 Event records

Each event includes time and clock-sync state, hangar ID, software configuration, aircraft ID, battery ID, bay, request ID, previous and new state, operator identity, alarm code and recovery action. The local console retains at least 90 days of event history. Export rights are role-controlled; camera footage is handled under the customer's site data policy.

10.2 Shift handover checklist

Item	Record
Hangar state and active mission	State, mission ID, any planned return
Aircraft identity and location	ID, flight status, battery ID
Battery inventory	Four module IDs, bay/aircraft locations, charge eligibility
Active and recent alarms	Code, cause, assigned recovery owner
Maintenance actions	Work performed, affected functions, return-to-service check
Site conditions	Weather, access restriction, power/network condition

10.3 Terms

Eligible module: A battery whose identity, charge, health, temperature and mechanical conditions permit selection for flight. **Receiving bay:** The empty bay reserved for the returning aircraft's used module.

Aircraft-ready handover: The hangar's confirmation that exchange and ground-handling conditions are complete; flight authorization remains subject to the aircraft controller and site operator. **Controlled abort:** An orderly stop at a defined safe stage. **STOP alarm:** A condition that prevents further mission progression until authorized recovery.

10.4 Customer site acceptance and training record

The handover record identifies the equipment and verifies the following functions in the installed configuration: roof open/close indication; deck position and aircraft retention; empty receiving bay; battery identity and eligibility; charge start/stop feedback; ground propulsion inhibit; exchange stage feedback; emergency stop and access interlock; local and remote status; both camera views; alarm history; and the aircraft-ready handover. The customer operator and service technician receive role-specific training on normal operation, emergency response, battery quarantine and recovery ownership.

Record field	Entry required at handover
Hangar serial and location	Asset ID, site, supply circuit and network connection
Aircraft and battery IDs	Aircraft revision, four matched modules, fitted-module drawing/charge-profile revisions and bay assignment
Software and safety configuration	Version, configuration ID and recorded emergency-stop/access-interlock function checks
Functional results	The installed unit's site acceptance results and open service items

Record field	Entry required at handover
Training	Names, roles, date and topics completed
Sign-off	Customer representative and SOLARTODO representative



STT-HUB1101 at a glance: independent four-bay hangar, guided fixed-contact battery exchange, monitored high-rate charging, closed-enclosure IP65 protection, local and remote supervision, and an emergency-stop/access-interlock architecture with a PL e / Category 4 design basis.

11. State and Permission Reference

11.1 State model

The operator console names one primary hangar state at a time. Battery charging, camera availability and network connection are separate status dimensions. A charging module does not make the hangar READY; a READY hangar does not imply that every stored module is eligible. The Home page shows the primary state, its entry time and the condition that blocks the next transition.

From state	Requested event	Required physical confirmations	Result
STANDBY	Run Self-Check	Access closed, emergency stop reset, roof/deck/tool positions known, battery ledger consistent	READY or FAULT
READY	Start Return	Receiving bay free, landing path clear, site and aircraft return permission present	RECOVERY
RECOVERY	Aircraft touchdown	Correct aircraft identity, within alignment limit, retention engaged and ground propulsion inhibited	AIRCRAFT SECURED
AIRCRAFT SECURED	Start Exchange	Eligible replacement module, free receiving bay, tool clear, charge stopped on any module to be moved	EXCHANGE
EXCHANGE	All transfer stages complete	New battery latch and contacts confirmed, old battery stored, ledger reconciled, tool clear	AIRCRAFT READY
AIRCRAFT READY	Handover	Deck at release position, local exclusion zone clear, aircraft controller ready, site authorization present	READY after aircraft departure
Any ground state	Safety fault or conflicting feedback	Fault condition is latched and last physical positions are retained	FAULT
STANDBY / FAULT	Enter Service	Authorized service role and safe access conditions	SERVICE

The controller records every attempted transition with a request ID. A request accepted by the console means that the controller has begun evaluating its guards. The new state appears only after the physical feedback for that transition has been confirmed. A timeout is an alarm, not permission to presume completion.

11.2 Exchange stage reference

Stage	Required entry state	Motion or control action	Independent completion evidence	If completion is absent
E01 Capture	RECOVERY	Retain landed aircraft	Retention feedback and position window	Block deck movement; A201
E02 Inhibit	AIRCRAFT SECURED pending	Request ground propulsion inhibit	Aircraft inhibit feedback distinct from request acknowledgement	Block battery handling; A202
E03 Lower	AIRCRAFT SECURED	Move deck to exchange height	Deck exchange-position feedback	Stop transfer; A102
E04 Stop charge	EXCHANGE	Stop channel of selected stored module	Current and stop-state feedback	Keep module seated; A402
E05 Remove old	EXCHANGE	Unlock, grip and withdraw used module	Aircraft latch release plus held-module identity	Hold position; A301/A303
E06 Deposit old	EXCHANGE	Place used module in receiving bay	Bay support, presence, ID and tool-clear feedback	Hold position; A301
E07 Pick eligible	EXCHANGE	Grip selected charged module	Bay identity transfers to tool once	Hold position; A301
E08 Insert new	EXCHANGE	Seat and lock new module	Aircraft lock plus stable electrical contact	Block handover; A303
E09 Clear tool	EXCHANGE	Retreat tool to parked position	Tool-clear feedback; no held module	Keep deck movement inhibited
E10 Present	EXCHANGE	Raise deck to release height	Deck position and aircraft retention status	Block handover; A102

Stage	Required entry state	Motion or control action	Independent completion evidence	If completion is absent
E11 Flight handover	AIRCRAFT READY	Process the separately authorized Handover request after aircraft and site checks	Flight-release permission and final inventory retained	Keep aircraft on ground; review blocked permission

The 150 s exchange clock covers touchdown detection, E01–E10 and the transition to **AIRCRAFT READY**. E11 is a later flight-handover step and is not included in the mechanical exchange time.

At every stage, the aircraft module ID and each bay module ID must form a one-to-one location ledger. A module may be marked temporarily **IN TOOL** during transfer. The system never treats a disappeared ID as an empty module or advances by assuming where it went.

11.3 Control ownership

Control decision	Hangar controller	Aircraft controller	Operator / site
Roof, deck and transfer-tool motion	Executes and checks physical feedback	No motion authority	Requests permitted sequence and keeps area clear
Ground propulsion inhibit during exchange	Requires independent inhibit feedback	Applies and reports aircraft-side inhibit	Does not bypass absent feedback
Battery selection and charging	Selects eligible module; supervises bay charging	Reports aircraft battery information	Can mark a module unavailable
Takeoff authorization	Confirms hangar-side handover only	Performs aircraft flight checks and takeoff control	Grants site/airspace permission
Emergency stop on ground	Independent safety path stops hazardous hangar motion	Maintains its own safety behavior	Actuates stop; secures site; reports event
Post-fault restart	Requires reconciliation and self-check	Revalidates aircraft state where relevant	Supervisor or service authorizes return

11.4 Actions by role and state

Action	Operator	Supervisor	Service technician	Administrator
View status, video and alarms	Yes	Yes	Yes	Yes

Action	Operator	Supervisor	Service technician	Administrator
Start normal return/exchange/handover	READY path only	READY path only	READY path only	Configuration dependent
Pause or controlled abort	Active mission	Active mission	Active mission	Configuration dependent
Acknowledge alarm	Yes	Yes	Yes	Yes
Authorize restart after resolved fault	No	Yes	Yes	No
Isolate and inspect retained module	No	No	Yes	No
Use individual service movement	No	No	SERVICE only	No
Manage accounts and retention policy	No	No	No	Yes

An emergency-stop actuator is available independently of console login. A role assignment never overrides a physical interlock. Acknowledgement records that a person saw an alarm; it does not restore motion, discharge stored energy or clear the cause.

12. Complete Local-Console Reference

12.1 Global navigation and status conventions

The 10.1-inch local console presents Home, Mission, Batteries, Cameras, Alarms and Service in a fixed navigation bar. The persistent header shows model, hangar serial number, active role, local time and clock-sync condition, primary state, network condition and highest active alarm. All motion requests require a visible confirmation prompt showing the requested action and affected equipment. A command tile progresses through **REQUESTED**, **ACCEPTED**, **IN PROGRESS**, **CONFIRMED** or **FAILED**. The operator must use the physical completion indication before moving to the next step.

Visual state	Meaning	Operator interpretation
Green / READY or CONFIRMED	Required feedback is current and consistent	Proceed only with the next permitted action
Amber / WAIT or ACTION	A condition needs attention or a defined hold is active	Read the blocking reason; do not repeatedly press the control
Red / STOP or FAULT	Safety path or physical-state conflict	Keep clear; use alarm card and assigned recovery role

Visual state	Meaning	Operator interpretation
Gray / UNKNOWN or STALE	No current reliable feedback	Treat the affected permission as unavailable
Blue / IN PROGRESS	A commanded sequence is being supervised	Observe; do not enter the exclusion zone

The console retains the displayed last-confirmed physical state if connectivity is interrupted. The stale marker and last-update time remain visible until a fresh controller read is received. Color is paired with text and symbol so a color change is never the only indication.

12.2 Home page fields

Field	Display rule	Why the operator uses it
Primary state	State name, entry time and blocking reason	Establishes what can happen next
Aircraft card	Configured aircraft ID, presence, retention and ground inhibit	Prevents wrong-aircraft exchange
Roof and deck cards	Requested and confirmed position separately	Detects command/feedback disagreement
Transfer tool	Parked, moving, holding module ID or unknown	Identifies retained-load condition
Battery summary	Aircraft module, stored eligible count, receiving bay and quarantined count	Checks sustainable mission inventory
Power and network	AC available, charging allocation, local link and remote link	Explains limited functions
Top alarm	Priority, code, affected zone and first response	Directs immediate action
Self-check	Last run, result and failed subsystem	Confirms READY basis

Home controls: Run Self-Check is available in STANDBY and after authorized fault recovery. Controlled Stop is offered only where a safe stopping point is defined. A state tile opens its detailed feedback, including the last physical update time.

12.3 Mission page fields and buttons

The Mission page is organized as arrival, capture, exchange and handover. Each stage displays pending, active, passed or blocked. The page shows the selected aircraft, incoming module, chosen replacement module, receiving bay, request ID and stage duration. It also shows the last confirmed location of every module. A blocked stage names the missing guard and links to its alarm card.

Button	Available when	Expected result	Never implies
Start Return	READY and arrival path permitted	Roof/deck prepare and RECOVERY begins	Aircraft has landed
Start Exchange	AIRCRAFT SECURED and all guards pass	Ordered E03-E10 sequence to AIRCRAFT READY	Battery has already moved
Pause	A defined hold point is available	Supervised hold with physical state retained	Hazardous motion stopped immediately
Controlled Abort	State-specific abort path exists	Safe stopping sequence and final state report	Automatic restoration to READY
Handover	AIRCRAFT READY and external checks present	Hangar side of release completed	Aircraft takeoff or airspace clearance
Controlled Stop	No inbound aircraft or held module	Closed/parked stopping sequence	Electrical isolation

12.4 Batteries page fields

The first row identifies the aircraft battery. Four bay cards follow in physical bay order. An empty bay is explicitly labeled **RESERVED FOR RETURN** when designated as the receiving bay. A battery card displays module ID, physical location, SOC, SOH, temperature, cell spread, cycle count, charge current, charge stage, eligibility and active alarm. Selecting a card opens its last charge, last exchange, quarantine reason and location history.

Battery status	Selection for next flight	Charging behavior
ELIGIBLE	Permitted if aircraft configuration matches	May remain in supervised hold
CHARGING	Blocked until all flight checks pass	Current follows permitted charge profile
CONDITIONING	Blocked	Fast charge waits for temperature band
HOLD	Blocked pending defined check	Channel output stopped or limited
UNAVAILABLE	Blocked	Disabled by authorized operator action

Battery status	Selection for next flight	Charging behavior
QUARANTINED	Blocked	Disabled pending service inspection
UNKNOWN	Blocked	Channel de-energized until identity resolved

Mark Unavailable removes a physically known battery from automatic selection; it does not override a charge-stop or access interlock. **Restore Eligibility** is a service-controlled action after cause resolution and a complete eligibility check.

12.5 Cameras page fields

Camera 1 shows the landing aperture, aircraft and deck. Camera 2 shows the transfer tool, aircraft battery interface and bay region. Each pane carries camera ID, last-frame timestamp, online state and stream quality indication. The operator can select a single enlarged view or the two-view overview. The video pane never draws a safety-clear badge based only on image interpretation. If a stream is stale, the pane displays the elapsed stale time and the A701 entry point.

12.6 Alarms page fields

The active-alarm list sorts STOP before ACTION before ADVISORY. An alarm detail includes code, first/last occurrence, affected zone, state and exchange stage, immediate action, recovery owner, affected aircraft/module IDs and event sequence. **Acknowledge** requires a user identity and preserves the event. **Resolved** appears only after the actual feedback is normal and any required functional check passes. The History view supports date, code, asset and mission filters.

12.7 Service page fields

The Service page is role protected and shows current physical positions, independent safety feedback, retained-module location, charging output state, inspection entries and software/configuration identifiers. Before any individual movement, the page asks the technician to confirm area clearance and the supported load condition. Service commands show requested motion and separate physical completion. Closing Service mode requires a recorded affected-function check and full self-check.

12.8 Console response to loss of data

Lost information	Console behavior	Operating rule
Camera stream	Stale view with time and A701	Use the site's observation procedure; camera loss cannot satisfy a physical guard
Remote link	Local console retains current controller state	Remote users see stale status and cannot infer completion

Lost information	Console behavior	Operating rule
Battery telemetry	UNKNOWN / not eligible	No automatic selection or fast charge
Mechanism position feedback	FAULT / blocked movement	Service reconciliation before motion
Clock synchronization	Visible clock warning and monotonic event order	Preserve event IDs; correct site time before export

13. Detailed Mission and Exception Playbooks

Each playbook has an entry condition, operator action, completion check and stop point. Follow the current console instruction when it is more restrictive than the normal path. Keep the physical controlled area clear throughout roof, deck and transfer motion.

13.1 Begin a normal operating shift

Entry: hangar is powered or in STANDBY; no mission is active. **Operator:** inspect the landing approach, roof travel envelope, visible seals, deck and cameras; confirm no person or object is in the exclusion zone. Compare the aircraft ID and four module IDs with the site record. Confirm three stored modules at most and one free receiving bay. Review AC, network, active alarms and the last service entry. Run Self-Check. **Completion:** Home is READY, all required physical feedback is current and the shift checklist is signed. **Stop point:** any unknown module, open safety path, active STOP alarm or missing receiving bay.

13.2 Prepare for return

Entry: READY, aircraft identified, an eligible replacement module available and site return permission recorded. **Operator:** confirm the intended landing area and weather with the flight team; press Start Return once. Watch roof-open and deck-reception confirmation. Keep other aircraft and personnel clear. **Completion:** RECOVERY with roof and deck feedback confirmed. **Stop point:** A101/A102, lost aircraft identity, unsafe approach condition or interrupted safety path. Request Controlled Abort if the state allows it; otherwise use the alarm instruction.

13.3 Verify capture and ground safety

Entry: aircraft has touched down. **Operator:** wait for location, retention and propulsion-inhibit feedback; compare aircraft ID on the console to the mission record. Use the landing camera as an observation aid. **Completion:** AIRCRAFT SECURED appears with capture and inhibit shown as independently confirmed. **Stop point:** aircraft off center, moving, wrong identity, capture absent or ground inhibit absent. Keep hands out of the enclosure and do not issue Start Exchange.

13.4 Supervise battery exchange

Entry: AIRCRAFT SECURED; one free bay and a selected ELIGIBLE module. **Operator:** check the old battery ID, replacement ID and destination bay. Issue Start Exchange once. Track the E03–E10 stages; each must show confirmed feedback before the next begins. Note any unexpected stage duration or inventory change. **Completion:** AIRCRAFT READY, new module on aircraft, old module in bay, transfer tool clear and no active blocking alarm. **Stop point:** stage timeout, held module, duplicate identity, latch/contact disagreement or charge-stop uncertainty. Preserve current state and call service; never send a second exchange request to clear the first.

13.5 Release the aircraft

Entry: AIRCRAFT READY; hangar mechanism clear. **Operator:** verify the actual aircraft battery ID and eligible status, deck release height and roof position. Obtain aircraft-controller flight-ready indication and site flight permission. Clear the departure volume; then submit Handover. **Completion:** hangar handover is confirmed and the flight team records aircraft departure. **Stop point:** any new hangar fault, aircraft preflight fault, personnel in the controlled area or lost site authorization.

13.6 A return is cancelled before touchdown

Entry: RECOVERY, no aircraft has been captured. **Operator:** confirm the aircraft remains outside the aperture and the flight team controls its next action. Request Controlled Abort. Wait for the deck and roof to reach their confirmed parked positions. **Completion:** STANDBY or READY as displayed, with no active mission and the battery ledger unchanged. **Stop point:** aircraft position uncertain, roof obstruction or position feedback mismatch; do not repeatedly close the roof.

13.7 A mission is paused after capture

Entry: AIRCRAFT SECURED or a defined exchange hold point. **Operator:** press Pause once and read the resulting hold state. Maintain aircraft propulsion inhibit and personnel exclusion. Record the aircraft, battery and tool locations. The supervisor decides whether to resume, controlled-abort or assign service. **Completion:** a named hold point with all physical positions known. **Stop point:** module in tool, charge state unknown or unexpected motion; follow the corresponding STOP alarm.

13.8 A module is held by the transfer tool

Entry: EXCHANGE has stopped and the tool reports a module in its grip or location feedback is uncertain. **Operator:** stop all new mission requests, keep access closed and record the module ID and position. Do not lower the deck, move the roof or re-run the exchange. **Service:** isolate relevant energy, support the load, compare mechanical position with the ledger and use a controlled recovery sequence. **Completion:** module secured in a known bay or aircraft position, tool clear, ledger reconciled, affected-function check passed. **Stop point:** any unresolved support, identity or charge isolation condition.

13.9 Mains failure during standby or charging

Entry: AC supply lost or unstable. **Operator:** mark the hangar unavailable for inbound aircraft; tell the flight team that landing/recovery availability has changed. Do not open the enclosure to disconnect a battery. On return of power, check the displayed last-confirmed bay and charge states before restarting. **Completion:** service or supervisor completes the power and charger checks and Self-Check returns READY. **Stop point:** any module temperature, identity or charge-current mismatch.

13.10 Mains failure during exchange

Entry: AC supply lost while the deck or tool is moving or holding a module. **Operator:** treat position and retained load as unknown until local indicators confirm otherwise. Keep people clear, do not command a restart and inform qualified service personnel. **Service:** inspect supported loads and energy isolation, restore power under site procedure, read independent positions and reconcile the battery ledger. **Completion:** all physical locations known and affected movement verified before full self-check. **Stop point:** any mismatch between displayed and physical locations.

13.11 Extreme weather or site access intrusion

Entry: precipitation, wind, contamination or unauthorized entry compromises recovery or takeoff. **Operator:** suspend new returns and alert the flight team. If no aircraft is in the aperture, request a controlled stop and roof closure. If an aircraft is inbound or captured, use the state-specific safe hold and site flight contingency. **Completion:** weather and site conditions restored, roof/deck checked, Self-Check READY. **Stop point:** do not command closure around an aircraft or person.

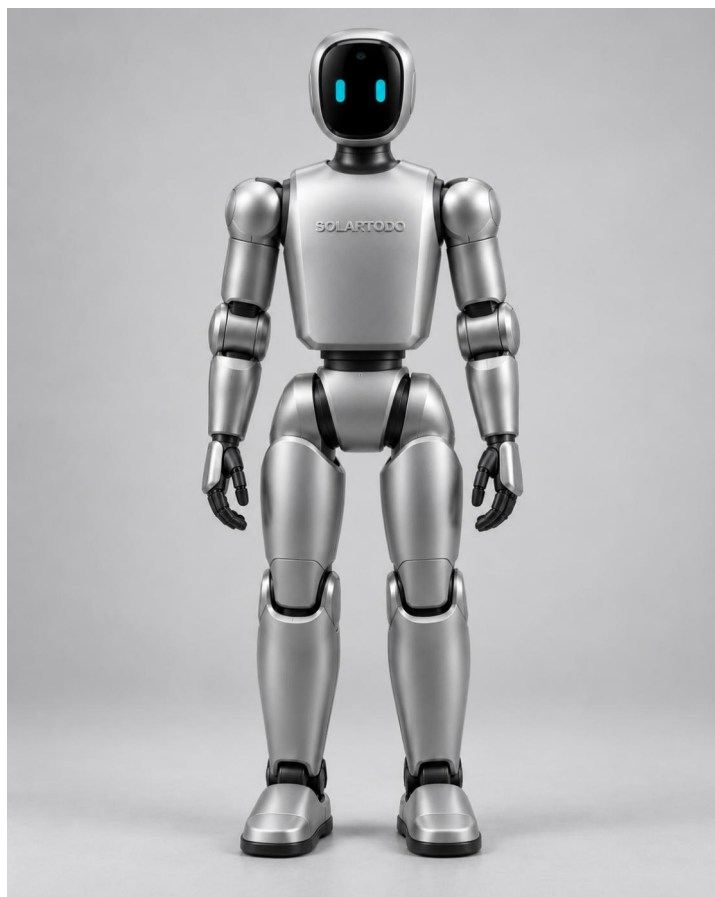
13.12 End an operating shift

Entry: no inbound aircraft; tool is clear and battery locations are known. **Operator:** record aircraft location and all four module IDs; review charge and quarantine states; export any required events. Request Controlled Stop, wait for roof closed and deck parked, then leave the unit in the site's defined standby or isolated condition. **Completion:** handover sheet records state, alarms, battery eligibility and next planned mission. **Stop point:** unresolved retained module, open roof, active STOP alarm or unassigned battery location.

PART IV

STTBOT Humanoid Robot Family

Two sizes, one visual identity and a common air-ground task interface.



STTBOT family exterior; model dimensions and end effectors are specified separately.

R1. STTBOT Family Overview

STTBOT-S1 and STTBOT-T1 are bipedal ground robots with a shared exterior design and a common SkyHub task interface. S1 is the compact 880 mm class; T1 is the 1320 mm class with a larger body and arm capability. Each robot can receive an approved ground task, report its operating state, use depth and 3D range sensing for local awareness, and return to its own 200 W wireless charging position. The site configuration identifies the fitted end effector, audio option and battery pack.



STTBOT-T1 front and side exterior views. STTBOT-S1 shares the family form at a smaller scale and uses the two-finger end effector specified for S1.

R1.1 Ground mission roles

Task	Robot contribution	Coordination condition
Ground inspection	Observe accessible equipment, doors, corridors and surface-level anomalies	Task area and walking path reviewed by operator
Aerial event follow-up	Visit a location identified by the UAV and provide a ground-level view	Common event ID and safe separation from aircraft recovery volume
Remote observation	Send local status and selected observations to the site console	Access and export follow the customer's data policy
Service assistance	Carry or manipulate permitted light items within model and posture limits	Configured end effector and human supervision for physical contact

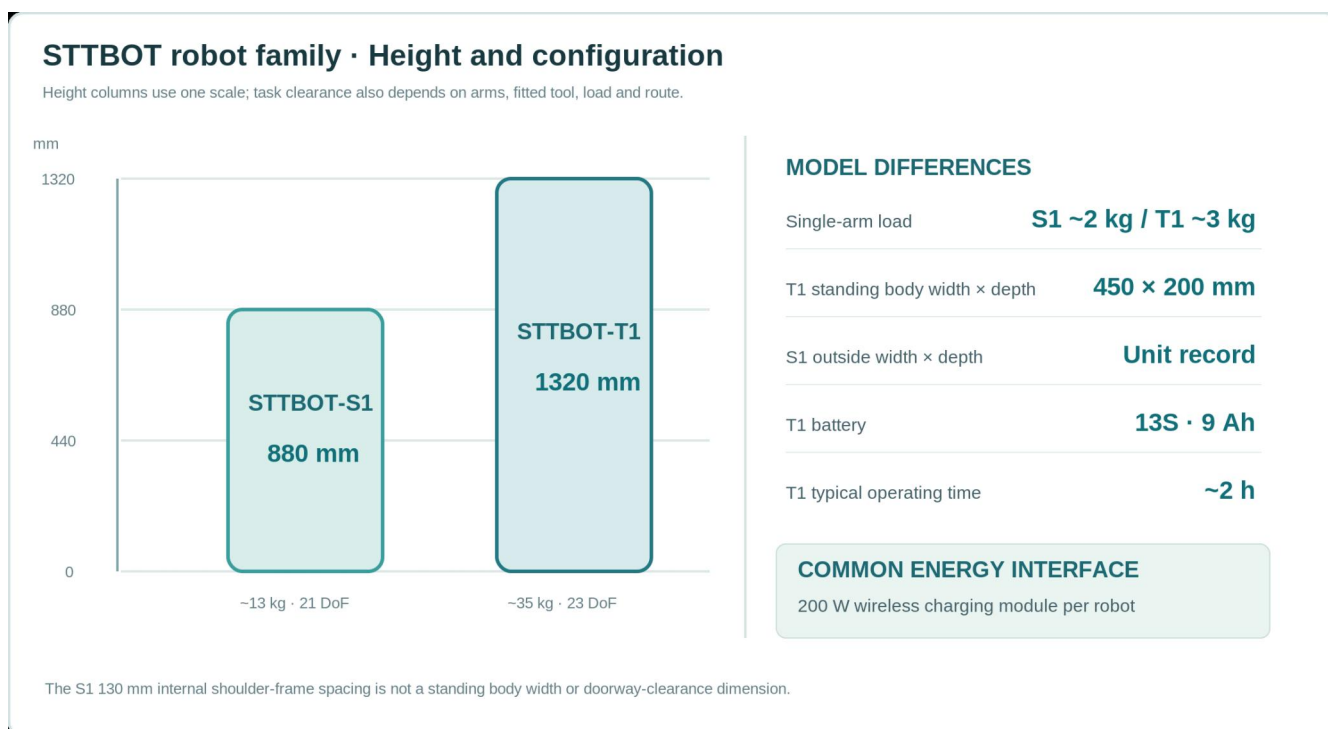
Task	Robot contribution	Coordination condition
Automatic return for energy	Navigate to assigned charging position and request charge	Dock alignment, foreign-object check and BMS permission

Robots do not enter the aircraft's landing and rotor exclusion zone while the cabinet is receiving or releasing the UAV. A robot task that requires contact with infrastructure or a person receives a separate operator decision under the site's procedure.

R2. Model Comparison

Whole-robot parameter	STTBOT-S1	STTBOT-T1
Standing height	Approximately 880 mm	1320 mm
Mass including battery	Approximately 13 kg	Approximately 35 kg
Standing width × depth	Delivered-unit configuration record; 130 mm refers to internal shoulder-frame spacing	450 × 200 mm
Folded dimensions	Recorded for the supplied unit	690 × 450 × 300 mm
Total active degrees of freedom	21 in base configuration	23 in standard configuration
Leg degrees of freedom	6 per leg	6 per leg
Arm degrees of freedom	4 per arm	5 per arm
Waist degrees of freedom	1 yaw	1
Arm load	Approximately 2 kg per arm	Approximately 3 kg per arm; varies with posture
Arm reach description	300–400 mm effective reach, including two-finger end effector	Approximately 450 mm specified arm span
Standard end effector	Two-finger end-effector configuration	Standard configuration has no independent dexterous-hand degrees of freedom
Locomotion	Bipedal walking	Bipedal walking
Battery	48 V nominal; quick-release/expandable smart-battery solution, capacity by supplied configuration	13-series, 9,000 mAh quick-release smart battery
Typical operating time	Defined by the supplied battery, compute mode and task load	Approximately 2 hours typical
Wireless charging	200 W contactless module	200 W contactless module

Whole-robot parameter	STTBOT-S1	STTBOT-T1
Audio	Ring microphone array and speaker integration available	Four-microphone array and 5 W speaker



Model height and configuration comparison. The supplied-unit record gives the S1 outside envelope and the actual tool fitted to each robot.

The S1 shoulder-frame spacing is not an overall body width and is therefore not compared directly with the T1 width. S1 effective arm reach and T1 arm span use different measurement definitions. Arm load depends on reach, posture and the permitted motion profile. The site configuration sheet records the actual end effector and carried tool.

R2.1 Common perception, computation and connectivity

Capability	STTBOT-S1 and STTBOT-T1 specification
Onboard AI compute	16 GB edge AI compute platform; up to 157 sparse INT8 TOPS / 78 dense INT8 TOPS module peak capability
Stereo depth sensing	Active-infrared stereo depth with 0.10 m to beyond 20 m module range; recommended working range approximately 0.26–3 m
Depth image	Up to 1280 × 800 at 30 frames/s
RGB image	Up to 1920 × 1080 at 30 frames/s

Capability	STTBOT-S1 and STTBOT-T1 specification
Depth field of view	Approximately 90° horizontal × 65° vertical
RGB field of view	Approximately 86° horizontal × 55° vertical at 16:9
Inertial sensing	Six-axis IMU within the depth assembly; robot motion state also uses its joint and balance feedback
3D range sensing	360° horizontal view; approximately -7° to +52° vertical view
3D range	Approximately 40 m on a 10% reflectivity target; 100 m maximum module range
Point output	Up to 200,000 points/s first return; typical 10 Hz point-cloud frame rate
Laser product classification	Class 1 at 905 nm for the specified range-sensing assembly
Wireless link	Wi-Fi 6 and Bluetooth 5.2
Wired/service link	Ethernet and USB with controller-specific expansion
Software interface	SDK, motion-control and ROS/ROS 2 integration according to the supplied configuration and authorized access

Compute TOPS and sensor range ratings describe their respective installed assemblies. Whole-robot detection distance and task performance depend on the configured model, scene and route. The robot controller uses local perception and balance checks before motion; no single camera image replaces joint, contact or emergency-stop feedback.

R2.2 Model-specific mechanical and movement specification

The dimensions below describe the robot models. Standing mass includes the battery as specified for each model. The S1 specification gives an approximately 130 mm internal shoulder-frame spacing, which cannot be used as the robot's outside width, corridor-clearance width or shipping width. The delivered-unit record carries the S1 outside width and depth, the fitted hand envelope and its transport posture. T1's stated 450 × 200 mm standing width and depth also require clearance around moving arms and people during a task.

Operating characteristic	STTBOT-S1	STTBOT-T1	Consequence for task planning
Standing height / battery-included mass	Approximately 880 mm / 13 kg	1,320 mm / approximately 35 kg	Confirm ceiling, doorway, floor and handling conditions against the supplied unit.

Operating characteristic	STTBOT-S1	STTBOT-T1	Consequence for task planning
Standing width × depth	Overall envelope recorded for the supplied unit; 130 mm is shoulder-frame spacing only	450 × 200 mm body reference	Add arm swing, end-effector, carried item and supervised clearance to the body reference.
Folded / transport envelope	Recorded for the supplied unit	690 × 450 × 300 mm	Use the specified transport posture; do not treat folded dimensions as a walking envelope.
Active joints	21: six per leg, four per arm and one waist yaw	23: six per leg, five per arm and one waist	A task profile must be matched to its own model and joint configuration.
Single-arm working description	Approximately 300–400 mm effective extension, including the two-finger end effector	Approximately 450 mm specified arm span	These are different measurement definitions and are not a like-for-like reach comparison.
Single-arm load	Approximately 2 kg	Approximately 3 kg, varying with extended posture	Include the fitted tool and grasped item; reduced reach and stable posture govern the allowed task.
End effector	Two-finger configuration	Standard configuration has no independent dexterous-hand degrees of freedom	The unit record identifies its actual hand, grip surfaces and permitted object types.
Base movement	Bipedal walking, standing, squatting and configured dynamic motions	Bipedal walking, standing, squatting and whole-body motions	Site route, carried load and human separation are part of the approved task profile.

The T1 specification gives waist rotation of $\pm 155^\circ$, knee movement of $0\text{--}165^\circ$, and hip pitch $\pm 154^\circ$, roll -30° to $+170^\circ$ and yaw $\pm 158^\circ$. These are joint ranges, not instructions to command a loaded arm or leg to the end stop. S1's corresponding angular limits are set by its delivered joint-limit profile and are not copied from T1. Arm-load figures describe maximum model capability under suitable posture; they are not permission to carry that mass while walking, reaching overhead or turning beside a person.

The approved mobility profile records permitted route width, floor condition, walking speed, slope, step or threshold, load posture and stopping zone for the installed robot. Speed, slope and step limits are set for each delivered robot and route. Route approval uses that profile and a clear walking path; a camera's maximum range is not an obstacle-clearance rating.

R2.3 Perception, Computing and Connectivity

The sensing stack combines color view, stereo depth, 3D range, inertial and joint feedback. Each stream has its own coverage and failure mode. The console presents stream health and age separately so an operator can see whether an observation has a usable source at the task location.

Data stream	Product-level value	Operator use and limit
Color scene	Up to $1,920 \times 1,080$ at 30 frames/s; approximately $86^\circ \times 55^\circ$ view in 16:9 mode	Ground-level visual review; light, occlusion and moving subjects affect the usable image.
Stereo depth	Up to $1,280 \times 800$ at 30 frames/s; approximately $90^\circ \times 65^\circ$ view	Local geometry for positioning and obstruction awareness; recommended working range is approximately 0.26–3 m.
Depth range declaration	0.10 m to beyond 20 m for the sensing assembly	Extreme sensor range is not a promised robot obstacle-recognition or object-identification distance.
3D range scene	360° horizontal; -7° to $+52^\circ$ vertical; typical 10 Hz cloud and up to 200,000 first-return points/s	Local range and route context; near-field blind zone approximately 0.1 m.
Range distance declaration	Approximately 40 m on a 10% reflectivity target; 100 m cutoff	Reflectivity and visibility change returns; the 100 m cutoff is not a guaranteed detection distance.
Inertial and joint state	Six-axis inertial sensing within the depth assembly plus robot joint/balance feedback	Motion control uses robot-local feedback; a valid camera picture alone does not authorize walking.
Onboard compute	16 GB memory, with module peak up to 78 dense or 157 sparse INT8 TOPS	Compute figures state processing capacity, not a measured site recognition accuracy or response latency.
Communication	Wi-Fi 6 / Bluetooth 5.2; Ethernet/USB and configured controller expansion	Console shows transport, last update, command receipt and actual device state separately.

The 3D range return, depth image and color image are complementary. A dark, reflective or occluded surface can make a local region uncertain even when another sensor remains healthy. The robot reduces or holds a task according to its local confidence and site profile, and the operator sees the affected stream, last valid update and the blocked action. Time synchronization and source timestamps accompany observations handed to the shared air-ground event. Perception or AI output can prioritize a ground review; it does not itself grant authority to touch infrastructure or a person.

R3. Mobility and Manipulation

R3.1 Motion states

State	Meaning	Operator control
OFF / ISOLATED	Motion power unavailable	Service and transport only
BOOTING	Controller, balance and perception checks underway	Observe; keep area clear
STANDBY	Stable posture, no active movement task	Review status or request a task
READY	Route and safety checks passed	Approve walking or teleoperation
WALKING	Approved route or supervised control active	Monitor people, terrain, link and battery
TASK HOLD	Robot has stopped at a defined hold condition	Resolve cause; do not force a resume
RETURNING	Robot is proceeding to assigned parking/charging position	Keep route and dock clear
DOCKING	Fine alignment and charge permission checks active	Avoid standing between robot and dock
CHARGING	Wireless power transfer supervised by BMS	Monitor power, temperature and foreign-object status
FAULT	Balance, joint, energy or safety condition prevents normal task	Apply alarm-specific response

S1 has 21 active degrees of freedom arranged as 12 leg, eight arm and one waist axis. T1 has 23 arranged as 12 leg, ten arm and one waist axis. The robot's permitted walking speed, slope, step height and carrying posture are constrained by its delivered mobility profile and task area; the operator chooses a route that is within that profile. Do not infer obstacle clearance from the maximum depth-camera or range-sensor distance.

R3.2 Physical-task boundary

The site console can request an observation route or an approved manipulation task. Local balance and contact control remain on the robot. The operator verifies that the selected tool, arm pose and payload fit the model's configuration. S1's two-finger tool and T1's standard hand configuration are not interchangeable merely because the exterior family looks alike. If a target object is uncertain, a person enters the path or the robot loses balance confidence, the task is held and a supervisor reviews the scene.

R3.3 Selecting the robot and its task profile

Decision before dispatch	S1 selection	T1 selection	Common release condition
Access and body size	Compact 880 mm height is useful at low accessible points; actual external width still comes from its unit record	1,320 mm height and 450 × 200 mm standing body reference support taller access	Verify the complete walking and arm envelope, floor, people and the selected parking posture.
Ground observation	Compact body height can suit lower accessible positions when the installed camera viewpoint and site profile permit	Taller body and the model's longer arm working description can suit higher accessible positions	Confirm actual viewpoint, sensor health, fresh localization and event ID.
Object handling	Two-finger tool; approximately 2 kg single-arm limit at a permitted pose	Configured standard hand/tool; approximately 3 kg single-arm limit at a permitted pose	Verify object mass including grasp hardware, reach, balance and a separate contact authorization.
Energy	48 V pack; runtime is calculated from the installed pack and mission load	13-series 9 Ah pack; approximately two hours typical in the T1 product specification	Keep the return-to-park energy policy and dock route available before dispatch.

An aerial event may assign a robot to approach the accessible ground side of the same location. The shared event identifies the UAV observation, the robot's route and each viewpoint's timestamp. The robot can report visual and geometric findings, then request an authorized physical-service task if needed. It does not inherit an aircraft clearance or permission for contact from the air task. A different robot model, tool or route requires a new task-profile check rather than an automatic reassignment.

R4. Power and 200 W Wireless Charging

Both robot models include a 200 W contactless transmitter/receiver charging system. The transmitter is supplied from a nominal 48 V DC charging position; the receiver output is configurable from 48 to 54.6 V DC up to 200 W. The battery-management system supervises the charge profile. Charging status, power, temperature and faults can be reported through the configured UART or CAN interface.

Charging parameter	Product specification
Rated wireless transfer power	200 W
Coupling	Near-field magnetic inductive / resonant transfer
Suggested operating gap	5–15 mm; preferred 8–10 mm

Charging parameter	Product specification
Lateral alignment	Approximately ± 10 mm, subject to dock geometry
Transfer efficiency	At least 85% at specified alignment; typical 88–90% in favorable alignment
Receiver output	Configurable 48–54.6 V DC, maximum 200 W
Charge control	BMS-linked start/stop and monitored constant-current/constant-voltage profile
Protective functions	Input/output voltage, overcurrent, short circuit, overtemperature, undervoltage and foreign-object detection
S1 pack	48 V nominal; supplied capacity and charge limit recorded per unit
T1 pack	13-series 9 Ah smart pack; nominal energy estimate is 432.9 Wh when 3.7 V per cell is used for calculation
T1 wired charger	54 V / 5 A configuration

The 200 W value is a wireless-transfer rating. Battery charging power can be lower because of alignment, transfer loss, battery temperature and the BMS charge profile. The console therefore reports a live charge-power value and estimated completion for the installed pack instead of deriving a fixed charge time from 200 W alone. S1 pack capacity is part of the purchased configuration; T1's approximately two-hour operating time is a typical value and changes with walking, perception, compute and arm use.

R4.1 Normal return-to-charge sequence

1. Robot energy policy marks RETURNING and requests an available charging position.
2. The site console checks that the route and docking area are clear of people, loose metal and obstruction.
3. The robot approaches at its permitted low-speed docking profile and confirms its parking posture.
4. The dock checks coil position and foreign-object state. The BMS reports battery identity and permission.
5. Wireless transfer starts; the console displays actual power, battery temperature and charge state.
6. On completion, hold or fault, the power-transfer state is reported and the robot remains unavailable for a new mission until readiness checks pass.

If lateral offset or air gap is outside the configured window, the robot does not compensate by repeatedly forcing contact. It stops, records the reason and asks for inspection or a controlled repositioning request.

R4.2 Battery energy, task reserve and charge-time calculation

The T1 product specification lists a 13-series, 9 Ah smart battery and approximately two hours of typical operating time. **At 3.7 V nominal per cell for energy planning**, $13 \times 3.7 \text{ V} = 48.1 \text{ V}$ and $48.1 \text{ V} \times 9 \text{ Ah} = 432.9 \text{ Wh}$ **nominal calculated pack energy**. Dividing that energy by two hours gives **216.45 W equivalent average whole-robot power** for the same planning condition. Actual consumption varies with arm motion, compute mode, wireless use, floor and posture. The BMS-reported usable energy and current task estimate govern the return decision.

Planning quantity	T1 calculation or operating rule	S1 calculation or operating rule
Calculated nominal battery energy	Assuming 3.7 V/cell: $13 \text{ series} \times 3.7 \text{ V/cell} \times 9 \text{ Ah} = 432.9 \text{ Wh}$	$48 \text{ V nominal} \times \text{installed pack capacity in Ah}$; the delivered-unit battery record supplies that capacity.
Typical operating reference	Approximately two hours in the T1 product specification; calculated energy-balance average 216.45 W under the 3.7 V/cell planning condition	Task duration follows installed pack energy and recorded duty-cycle power.
Energy from 20% to 90% SOC	Under the same assumption, $432.9 \text{ Wh} \times 70\% = 303.03 \text{ Wh}$ before battery-health and temperature effects	Installed nominal Wh $\times 70\%$; this is an example SOC interval, not a universal charge policy.
20% to 90% ideal lower-bound charge duration	Under the same assumption, $303.03 \text{ Wh} \div 200 \text{ W} = 1.52 \text{ h}$ if 200 W were held at the battery terminals throughout	Installed interval energy $\div$ actual battery-terminal charge power.
Dispatch and return reserve	Live SOC, SOH, BMS limits, expected task energy and return-to-dock route are all checked	Same rule; no fixed runtime is inferred from 48 V alone.

The 1.52 h T1 value is an energy-only lower bound. The 200 W rating describes the wireless charging system, while actual battery-terminal power can be lower because of coupling efficiency, alignment, temperature and constant-voltage taper. The charging interface therefore shows commanded power, measured transfer power, BMS-accepted power, SOC, pack temperature and estimated completion separately. A 54 V / 5 A wired charger is specified for T1; its rating is not substituted for a verified full-charge endpoint or for the wireless charge curve.

At dispatch, the console compares the planned ground route and work duration with the live energy available after the required return and parking reserve. If a new task extends the route, adds a carried load or changes the allowed docking path, the energy check is repeated. A robot with a charge request but no confirmed power transfer remains in DOCKING or FAULT, not CHARGING. A battery identity or health fault blocks automatic assignment until the BMS and the installed-pack record agree.

R5. Robot Operating Interface

R5.1 Robot card and local controls

The site console presents separate S1 and T1 cards. Each card shows model and serial number, current posture/motion state, task ID, location and last update, battery identity and SOC, charge session, wireless transfer power, sensor and link health, active alarm, autonomy/teleoperation state and current operator. A robot may be selected for a task only when its capability, battery reserve, route and safety state meet that task's requirements.

Screen	Primary information	Permitted action
Fleet / Robots	S1/T1 location, readiness, battery and alarms	Open model card and compare available assets
Mission	Approved route, checkpoints, task state and observation	Request start, pause, return or authorized teleoperation
Perception	Depth/RGB/range health and local observation references	Review data permitted by role
Energy / Dock	SOC, BMS state, dock alignment, 200 W session and actual power	Request return-to-charge or stop after permitted check
Alerts	Severity, affected joint/sensor/energy path, first response	Acknowledge and assign recovery owner
Service	Configuration, software, joint and sensor diagnostics, maintenance log	Qualified role only

The console distinguishes a task request from physical walking, a dock request from alignment, and a charge request from actual transferred power. A remote view with stale telemetry cannot confirm safe motion. The supplied robot configuration requires a physical emergency-stop control and local balance protection independent of a remote UI session; the handover sheet records their functional checks.

Robot console: movement, energy, perception and safety fields.

R5.2 Robot status data dictionary

Every value on a robot card is tied to its robot ID and last device update. A blank or stale value is shown as unavailable, never silently carried forward as current. Numerical values carry their units; a task permission is shown separately from a sensor measurement.

Console field	Display and source	Operator interpretation
Identity and configuration	Model, robot serial, installed battery ID, tool ID and software/profile revision	Confirms that the selected capability and task restrictions belong to this unit.
Task	Event ID, task/request ID, route version, task purpose, current checkpoint and assigned operator	One shared event may contain several independent air and ground requests; retries retain identity.
Motion state	OFF, BOOTING, STANDBY, READY, WALKING, HOLD, RETURNING, DOCKING, CHARGING or FAULT	The physical state is read from the robot controller, not assumed from a submitted command.
Posture and joints	Stance/balance status, joint fault summary, affected joint, motion inhibit and emergency-stop state	A normal image feed does not clear a joint or safety inhibit.

Console field	Display and source	Operator interpretation
Position and route	Local pose/map position, route checkpoint, position confidence and last valid localization time	Location confidence and freshness determine whether the route can continue.
Ground perception	Color, depth and 3D-range health, last frame/cloud time and affected field of view	Shows which observation source supports the current task and which has degraded.
Battery	SOC %, SOH %, pack temperature, BMS permission and battery identity	Use live BMS limits and route reserve for a return decision.
Wireless charging	Dock ID, alignment gap and lateral offset, foreign-object state, transfer state, measured W and session ID	DOCKED, CHARGE REQUESTED and POWER TRANSFER ACTIVE are separate results.
Communication	Local control link, remote view link, last heartbeat, synchronization state and command response age	A stale remote view does not prove that a stop, return or charge occurred.
Alert	Exact robot alarm code, severity, first occurrence, inhibited action, owner and acknowledgement	Acknowledgement records awareness; physical recovery is verified separately.

The screen groups these fields by task, movement, energy, perception and safety. Status color always has a text label and timestamp. A red STOP condition shows the affected action and last confirmed posture; yellow ACTION requires an assigned response; an ADVISORY records degradation while the remaining permitted functions are stated explicitly. The interface does not present camera or AI confidence as a substitute for balance status or a clear walking path.

R5.3 Control request and confirmation sequence

Step in the console	Required display	What the operator may conclude
Prepare	Robot identity, task and route revision, energy reserve, sensor/link health and authorization	The request is eligible for submission only if all required conditions are current.
Submit	Request ID, operator, time, requested action and device-delivery status	The console sent a request; no physical movement is yet proven.
Device accepts or rejects	Controller response, reason code and current local safety state	Acceptance is permission to attempt the action, subject to local motion checks.
Execute	WALKING, RETURNING, DOCKING or CHARGING feedback with live pose or transfer W	Motion or charge has begun when the relevant physical feedback is current.

Step in the console	Required display	What the operator may conclude
Complete	Reached checkpoint/park, stable posture, stopped motion or confirmed charge result	The operator can close the robot portion of the task after final-state verification.
Fail or time out	Last confirmed state, timestamp, blocked action and alarm owner	Do not issue a blind duplicate movement command or assume the robot is stationary.

Start, pause, return, dock, teleoperation entry and shutdown are distinct controls with distinct permissions. The console asks for renewed authorization when an operator changes a route, physical-contact target, selected end effector or operating zone. Emergency stop is a local safety action and remains available independently of remote connectivity. The interface shows who holds teleoperation authority and requires a hand-back confirmation before autonomous movement resumes.

R5.4 Ground observation and shared evidence view

The robot's event view places its route and observation timestamp beside the UAV's aerial observation when both belong to the same event. The operator can compare a roof-level aerial finding with an accessible ground-level view without merging their separate source records. Each observation carries robot ID, location confidence, camera/range stream health, time synchronization status and an operator note. Selected event frames or clips follow the customer's approved export rule; continuous raw video remains in the local trust domain. A task conclusion records what was observed, what remains uncertain and whether a person authorized a subsequent physical action.

R6. Robot Operating Procedures

R6.1 Before each shift

Inspect the walking area, charging pad and pedestrian separation. Check the robot body, feet, joints, visible fasteners, end effector, sensor windows and battery latch for damage or debris. Compare the robot model, serial, battery configuration and software revision to the site record. Confirm adequate SOC and no blocking alarm. Run the robot's controller self-check; verify a stable posture before accepting a walking task.

R6.2 Start a ground observation task

1. Open the event in Mission Overview; read the location and intended observation area.
2. Select STTBOT-S1 or STTBOT-T1 according to access width, reach, arm load and the supplied tool.
3. Review route, floor condition, pedestrian activity, restricted areas, battery reserve and communication path.
4. Record the authorizing operator. Issue the task once and wait for controller acceptance and actual WALKING status.

5. Monitor route progress, perception quality, balance state and people near the robot. Pause if the task area changes.
6. At the observation point, collect only the evidence needed for the event and follow the site's access policy.
7. Request RETURNING and verify the robot reaches a known safe posture or charging position before closing the task.

R6.3 Teleoperation

Teleoperation is a supervised control mode for an authorized operator. Before entry, confirm the robot is stable, the route is clear and link latency/status are within the site policy. Show the active operator identity prominently on the console. A loss of control link triggers the configured robot hold or safe posture; it does not leave a movement command latched. Hand control back to autonomous task mode only after the operator and robot controller both confirm the transfer.

R6.4 Manipulation or object handling

Confirm the fitted tool and object mass, dimensions and access position. Keep the arm within the model's allowed posture and payload. Clear bystanders before contact. Issue one authorized task, observe grip/contact feedback and object condition, and stop if the object slips or force/pose feedback becomes inconsistent. A robot must not use an arm rated for a given load at a different reach or posture without the corresponding task limit.

R6.5 Shutdown and transport

Return the robot to a stable parking posture, end active motion and charging sessions, then follow its local shutdown sequence. Secure the battery and joints for transport according to the supplied configuration. T1's folded envelope is 690 × 450 × 300 mm; S1 transport dimensions are recorded on its delivered unit sheet. Before the next shift, compare physical posture and battery identity with the stored state.

R6.6 City ground-inspection operating card

Purpose: obtain a close ground view of an approved site location, such as an accessible enclosure, entrance, walkway or fixed-asset exterior. Aerial detection and ground inspection remain separate task actions within the same event.

1. Confirm event ID, location, source of the finding, time and the specific question the ground visit must answer. Select S1 or T1 using body clearance, observation height, tool, energy and the approved walking profile.
2. Inspect the route on the site map and at the operating position. Mark pedestrian conflict points, steps or thresholds, cables, wet or uneven surfaces, restricted areas and the aircraft recovery exclusion zone.
3. Verify current robot posture, localization, battery/BMS, depth and 3D-range health, local link and emergency-stop state. Record the route version and assigned operator before sending the request.

4. Submit the task once. Confirm controller acceptance and then actual WALKING state with a fresh position update. If the task stays at SUBMITTED or ACCEPTED, use the last confirmed robot state to investigate rather than issuing repeated walk commands.
5. At each checkpoint, compare location confidence, camera/depth availability, observed condition and time against the original aerial or fixed-sensor finding. A changed scene is recorded as a new observation.
6. At the observation point, stop in a stable posture. Record the relevant frame or observation reference, viewpoint, time, sensor health and the operator's finding. Do not touch an object merely because it appears anomalous in the image.
7. Request RETURNING or an approved onward task. Verify final parking posture, position and energy. Close the ground-task record with its finding, unresolved uncertainty and any authorized service request.

R6.7 Supervised physical-assistance card

1. Record the separate physical-action purpose, authorizing operator, object description and allowed contact area under the shared event.
2. Confirm the fitted end effector, grasp surfaces, object mass and dimensions, model-specific arm load, reach, posture, footing and space around people. Do not apply the single-arm maximum to an extended or moving posture without its approved task limit.
3. Bring the robot to a stable stopped stance and display the selected arm, contact target, motion profile and operator in control. Keep bystanders out of the arm and drop zone.
4. Execute one controlled action and watch grip/contact state, arm and balance feedback, object position and live stop control. Hold immediately on slip, unexpected contact, uncertain target identity or degraded joint feedback.
5. Place the object in the approved final state, release contact and verify the robot's stable posture. Record the actual result separately from the submitted action.

Physical assistance is bounded by the customer's site authorization. The robot's perception output may guide a human decision, but it cannot independently authorize contact with people, regulated infrastructure or a contested target.

R6.8 Charging and end-of-shift card

1. Check that the assigned dock is available, the approach path is clear and no aircraft roof/landing recovery zone intersects the route. Confirm pack ID, BMS status and the dock's power and foreign-object state.
2. Request RETURNING. Watch actual route progress and keep the pedestrian and dock approach clear. A reported return request is not a completed park.
3. Confirm DOCKING, stable parking posture, measured air gap and lateral alignment. The recommended gap is 5–15 mm, preferably 8–10 mm; the approximate lateral window is ± 10 mm, subject to the installed geometry.
4. Confirm BMS permission and active power transfer in watts before marking CHARGING. Review pack temperature, SOC and session ID through the charging interval.

5. At shift close, record final robot location, posture, SOC, dock/charge result, unresolved alarm, task count and any physical contact or fall. Handover an inhibited robot as out of dispatch service until the recovery owner signs its return.

R7. Robot Alarms and Recovery

Alarm family	Visible condition	Immediate operator response	Recovery owner
BALANCE / POSTURE	Unstable stance, unexpected fall or posture mismatch	Clear area; stop new motion requests	Qualified service technician
JOINT / DRIVE	Joint feedback, temperature or motion inconsistent	Hold task; do not force a movement	Service technician
OBSTACLE / PEOPLE	Path blocked or person enters controlled distance	Pause or reroute only with renewed approval	Operator
PERCEPTION	Depth, RGB, range or time-sync information stale	Stop tasks that depend on the lost sensor	Operator, then service
BATTERY / BMS	SOC, temperature, health or identity outside task conditions	Return or park; prevent further dispatch	Operator / service
DOCK ALIGNMENT	Gap or lateral offset not within charging window	Keep charging disabled; inspect approach and pad	Operator
FOREIGN OBJECT	Charging surface detects foreign material	Stop charge; keep people clear of the pad	Service technician
WIRELESS POWER	Voltage, current, short, thermal or communication fault	Stop session; do not force a restart	Service technician
LINK / REMOTE	Task command or status stale	Do not assume movement completed; use local state	Supervisor
SAFETY STOP	Emergency stop, access or other safety path open	Maintain exclusion zone; inspect before reset	Supervisor and service technician

R7.1 Recovery sequence

Record robot ID, task ID, exact location, posture, battery state, affected subsystem and alarm time. Determine whether the robot is stable and whether any carried object is retained. Keep bystanders clear. A qualified person resolves the physical cause, confirms current sensor and joint feedback, then runs the affected-function check and the full self-check. Acknowledging the alarm does not restore motion authority.

R7.2 Fall or unstable posture

Do not command repeated stand-up movements in a crowded or obstructed area. Secure the scene and check whether an object, cable, person or damaged limb prevents recovery. Service personnel assess the battery, joints and sensor alignment before any assisted righting or powered movement. Record the event and require a return-to-service check.

R7.3 Wireless charging fault

On foreign-object, temperature or electrical alarm, stop the session and confirm transferred power has ceased. Inspect the pad, robot receiver surface, alignment and battery-management report. Remove a foreign object only after the charging path is safe. A new charging request is permitted after the cause is corrected and the dock self-check passes; repeated restarts are not a remedy for unresolved alignment or thermal faults.

R7.4 Console alarm codes and dispatch effect

The robot console uses the following code families so that the event timeline, robot card and service record identify the same condition. STOP blocks the named action until the cause is corrected and the local self-check passes. ACTION requires an assigned operator or service response before the next affected task. ADVISORY keeps only the explicitly listed degraded functions available. A code identifies a condition; it is not a command to reset a robot.

Code / severity	Trigger shown to the operator	Immediate action and inhibited function	Restart evidence and owner
ROB-BAL-01 / STOP	Balance confidence lost, unstable posture or fall feedback	Clear people, hold motion and secure carried load; no walking or stand-up retry	Qualified service inspection of body, feet, joints, pack and sensors; controlled balance check, supervisor release.
ROB-JNT-02 / STOP	Joint position, drive current, temperature or command feedback inconsistent	Stop motion; do not force the affected arm or leg	Service resolves cause, checks joint feedback and affected movement, then controller self-check and release.

Code / severity	Trigger shown to the operator	Immediate action and inhibited function	Restart evidence and owner
ROB-EST-03 / STOP	Physical emergency stop or local safety path active	Keep exclusion area and all powered movement inhibited	Cause inspected at robot, safety path restored locally, self-check and authorized reset recorded.
ROB-PTH-04 / ACTION	Obstacle, person or route change prevents safe progress	Hold and reassess path; no automatic bypass into a new area	Operator verifies a clear route and submits an approved route revision.
ROB-LOC-05 / STOP	Localization or map confidence insufficient for the active route	Hold autonomous walking and preserve last known position	Restore local position with current sensor data; operator verifies route and controller accepts a new request.
ROB-SEN-06 / ACTION	Required color, depth or 3D-range stream absent or stale	Stop tasks dependent on that stream; show affected field of view	Sensor health and timestamp restored; operator rechecks observation task.
ROB-LNK-07 / ACTION	Control or status link stale, command outcome uncertain	Do not infer stop or completion; no blind duplicate request	Local state and last command reconciled by supervisor before new movement authority.
ROB-BAT-08 / STOP	BMS inhibits discharge/charge, pack identity mismatches or critical energy condition	Stop new dispatch; return or park only under local safe-energy policy	Battery identity, BMS fault and usable reserve checked; service release if pack was replaced or isolated.
ROB-DCK-09 / ACTION	Dock alignment gap or lateral offset outside installed window	No wireless power transfer; park/hold without repeated forced docking	Operator clears path and verifies controlled repositioning; alignment and dock self-check pass.
ROB-FOD-10 / STOP	Foreign object at wireless charging interface	Stop transfer and keep people clear of energized dock area	Service confirms power off, removes object safely, inspects surfaces and repeats dock self-check.
ROB-CHG-11 / STOP	Charge-path voltage, current, thermal or communication fault	Stop charging; do not request another charge cycle until cause is known	Service checks dock, receiver, BMS and actual zero-power state, then authorizes a new supervised session.

Code / severity	Trigger shown to the operator	Immediate action and inhibited function	Restart evidence and owner
ROB-TEL-12 / ACTION	Teleoperation link or active-operator authority lost	Robot uses local hold/safe posture; no latched remote movement	Supervisor confirms robot posture, active operator and link freshness before hand-back or re-entry.

The code record includes first and last occurrence, robot and battery IDs, event/task ID, affected location and joint or sensor, severity, blocked command, last confirmed posture, response owner, acknowledgement, corrective action and return-to-service time. Repeated events remain visible as a history; a successful acknowledgement does not erase the original fault sequence.

R7.5 Controlled recovery and return to service

1. **Secure:** stop the affected task through its local control path, keep people outside the robot's fall, arm and charging zones, and secure any carried item. Record the physical posture before moving the robot.
2. **Identify:** read the exact alarm code, subsystem, last good telemetry time, battery condition, route and last accepted command. Compare console state with the robot and dock where accessible.
3. **Correct:** the assigned operator may clear a route obstruction; a qualified technician handles balance, joint, battery, electrical or charger faults. Preserve a fault snapshot before a configuration change or power cycle.
4. **Verify:** repeat the affected-function check, battery/dock check if relevant, local safety and motion self-check, current localization and task-route assessment. A robot following a fall or impact requires a controlled standing and short walking check in a clear area.
5. **Release:** record the person and time authorizing return to service, the test result, remaining restriction and new task request ID. The original task is not silently resumed after a STOP condition.

R8. Robot Inspection and Maintenance

Interval	Check	Acceptance / record
Each shift	Feet, body panels, joints, end effector, battery retention, cameras, range window, alarms and dock approach	No visible damage or contamination; self-check ready
Weekly	Joint noise and motion history, foot wear, charging alignment, pad cleanliness, link and sensor status	No recurrent fault or abnormal heat; service ticket if degraded
Monthly	Battery health trend, charge-session power trend, perception calibration status, software/configuration record and event-log storage	Reconcile asset data and review deviations

Interval	Check	Acceptance / record
After fall, impact or service	Structure, joints, battery, sensor pose, balance check and affected task function	Qualified return-to-service record before dispatch

Use cleaning methods compatible with the exterior, optical windows and charging surfaces. Keep magnetic charging areas free of loose metal. Do not spray liquid into open joints or electrical interfaces. A software or end-effector change is recorded with its version, affected function, operator training and return-to-service check. The robot is not dispatched when a safety or balance-related alarm remains active.

R8.1 Robot operating and maintenance record

Record group	Fields retained for the customer	Review purpose
Asset identity	Model, serial, battery ID/capacity, end effector, dock ID, software and motion-profile revision	Prevent one model's dimensions, hand or route limits from being assigned to another.
Shift opening and close	Operator, site zone, physical posture, SOC/SOH, active alarms, sensor/link state and dock status	Demonstrate the robot's condition before and after use.
Mission	Event/task/request IDs, route revision, purpose, checkpoints, operator approvals, actual motion times and final location	Distinguish requested work from physically completed ground work.
Perception and evidence	Observation source, timestamp, location confidence, sensor-health status and controlled media reference	Preserve the viewpoint and limits of a ground finding.
Energy	Battery ID, charge session, starting/ending SOC, measured transfer W, pack temperature, BMS status and dock alignment	Show whether the robot actually replenished energy and identify charging trends.
Fault and intervention	Alarm code, first physical state, inhibited action, corrective action, affected-function test, release authority	Prevent an acknowledgement from being treated as a repair.
Wear and change	Feet, joints, outer covers, end effector, sensor windows, charge surfaces, battery retention and software/tool change	Support condition-based maintenance and a controlled return to service.

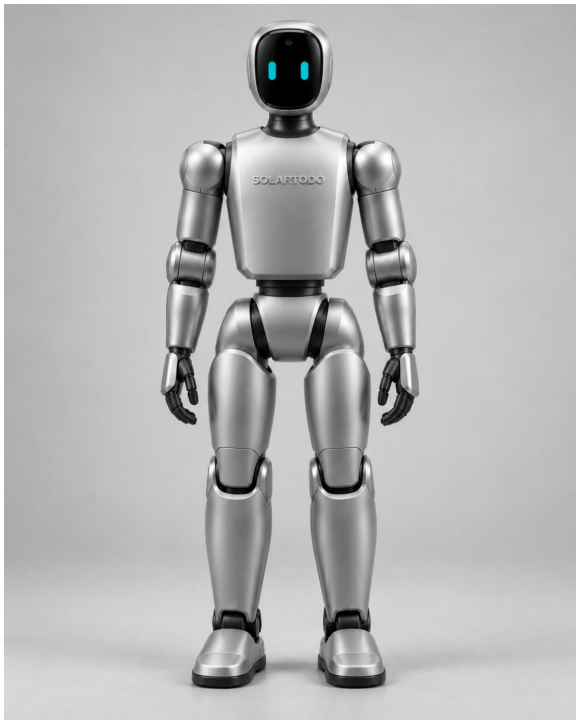
The weekly review compares joint and foot observations with previous shifts, counts repeated alarms and checks whether dock alignment or charging power has trended downward. The monthly review reconciles installed battery identity and capacity, route and end-effector profile, calibration status, user permissions, software revision and maintenance history. A trend requiring service is assigned an owner and disposition before the affected task is offered again.

R8.2 Return-to-service after a fall, impact or changed tool

After a fall or impact, record the robot's position, contact point, held object, first alarm and battery state. Isolate motion as needed, then inspect body panels, feet, joint housings, external cable openings, battery retention and sensor mounting. Check joint feedback and travel only under a qualified controlled procedure. Recheck local posture and balance, emergency stop, sensing and communication, then perform a short walking and stopping check in a clear approved area. The service record states which functions were checked and who released the robot. A tool, software or battery replacement adds an identity and task-profile check before the same return-to-service sequence.

R8.3 Delivered-unit and site-profile entries

The customer configuration sheet lists S1's measured outside width and depth, folded posture, installed battery capacity in Ah and Wh, fitted two-finger tool, and the local motion profile. T1's 450 × 200 mm standing body reference and 690 × 450 × 300 mm folded envelope are recorded with its installed end effector and 13-series 9 Ah pack. Both model records include serial number, dock, emergency-stop location, authorized teleoperation roles, walking area, route restrictions, software revision and sensor calibration reference. Site profile entries give each model its approved speed, floor, slope and threshold limits; the optics and charging-component ratings do not replace those whole-robot entries.



STTBOT-T1 front and rear exterior views. The site configuration identifies the delivered robot model, end effector, battery and options.

PART V

Coordinated Operations

One event, controlled task release, independent asset safety and a common completion record.

One mission record across air, dock and ground

SITE CONSOLE / LOCAL EDGE CONTROLLER

Event ID · human approval · task state · telemetry · alarms · evidence policy

STT 1S MAX

Aerial observation

Flight controller retains flight authority

STT-HUB1101

Four bays · exchange · charging

Physical interlocks govern ground motion

STTBOT-S1 / T1

Ground observation and service

200 W wireless charging

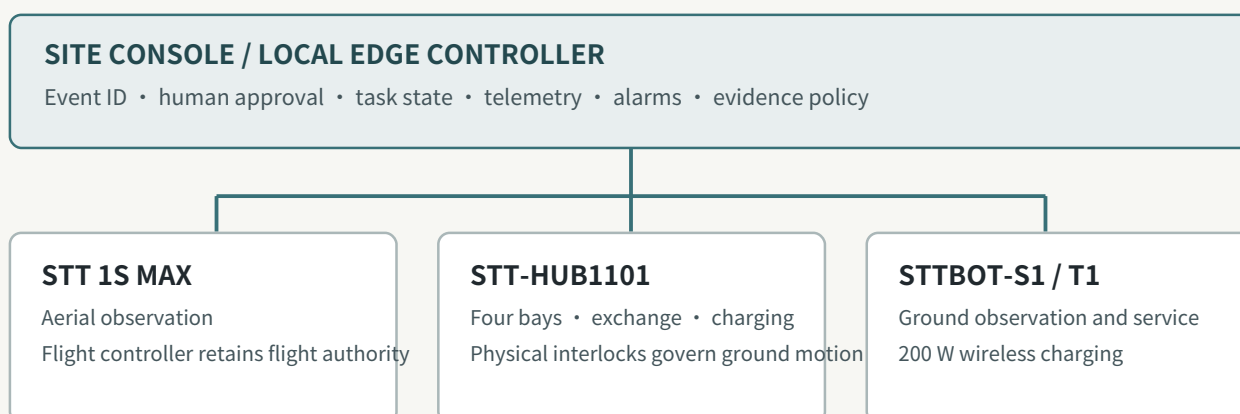
Each asset reports its own readiness and faults; no console command overrides a local safety condition.

C1. Air-Ground Operating Architecture

The SkyHub site controller connects the aircraft, STT-HUB1101 and the selected STTBOT robot through a common event and task record. Each asset retains its own local control and safety functions. The site console coordinates who should observe a location, whether a task is authorized, which energy and recovery resources are available, and how the result is recorded. The UAV gives an elevated view; the robot provides a ground-level view and limited physical service according to its fitted tool; the hangar restores aircraft battery availability.

Layer	Responsibility	Evidence shown to operator
Event intake	Receive site alarm, schedule or operator-created task	Event ID, source, time, location, severity
Review and approval	Decide whether an air or ground asset is appropriate	Operator, permitted area, task purpose and clearance
Resource planning	Check aircraft, hangar, module and robot readiness	SOC, health, free bay, dock, link and active faults
Task execution	Send permitted request and track independent device feedback	Accepted, in progress, physical/flight confirmation and alarms
Recovery and energy	Return aircraft to cabinet and robot to its charger	Landing, exchange, charging and final asset state
Closure and evidence	Record outcome and controlled media reference	Notes, timestamps, operator and export decision

One mission record across air, dock and ground



Each asset reports its own readiness and faults; no console command overrides a local safety condition.

C1.1 Common event and asset identifiers

The shared event ID is present on the UAV route record, cabinet exchange record, robot task, alarm and final report. Device records retain their own IDs as well: aircraft ID, battery-module ID, cabinet serial number, robot ID and charge-session ID. A new task request has a unique request ID; retrying a timed-out request without determining its physical result is prohibited. All timestamps include source clock and synchronization status.

Data field	Why it matters	Display content
Event ID	Links the air and ground response	EVT-260927-014
Task ID and version	Differentiates route or robot task revisions	TASK-0042-A, revision 3
Asset ID / model	Prevents S1/T1 or aircraft confusion	STTBOT-T1 / serial in site record
Location and freshness	Shows where the asset was and when	Map point plus last-update time
Battery identity and state	Couples mission to energy source	Module ID, SOC, SOH and alarm
Approval record	Shows who authorized the action and for what area	Role, user, time, permission type
Physical completion	Distinguishes command receipt from real outcome	Landed/secured, exchange complete, docked/charging

C2. Dispatch Rules and Resource Arbitration

C2.1 Choosing air, ground or combined response

Task need	Preferred asset	Additional check
Elevated roof or upper structure	UAV	Airspace, weather, route and cabinet recovery readiness
Indoor or ground-accessible route	S1 or T1	Passage width, floor condition, people and battery reserve
Wide-area overview followed by close inspection	UAV then robot, or approved parallel tasks	Shared event ID and separated operating zones
Battery replenishment	UAV with STT-HUB1101	Free receiving bay and eligible replacement module

Task need	Preferred asset	Additional check
Robot replenishment	S1/T1 with its wireless dock	Dock available, alignment and BMS permission

The console does not allocate the same cabinet bay, aircraft or robot to two active tasks. When the hangar is recovering an aircraft, the rotor and roof exclusion zone is reserved and a robot route cannot pass through it. When a robot is docking, the charging approach is reserved. A supervisor can reprioritize tasks, but the system preserves the original requests, approvals and reasons for the change.

C2.2 Release checklist for an aircraft task

Before release, check task area and purpose, route version, aircraft identity, flight-controller health, matched battery, energy reserve, weather, command link, observation payload, hangar state and an alternate recovery plan. Verify the operator, flight-responsible person and required site/airspace permission. The console then submits a request; actual launch is reported separately by the aircraft.

C2.3 Release checklist for a robot task

Before release, check the robot model, route width, floor, obstacles, people, lighting and local sensor availability. Review the end effector, posture-dependent payload, battery and docking plan. Confirm an operator is assigned for any physical contact or teleoperation. The robot reports actual walking only after its local balance and motion controller accepts the task.

C3. Coordinated Operating Scenarios

C3.1 Scheduled site inspection

Trigger: a planned inspection window opens. **Review:** the operator identifies elevated points and ground-accessible points, checks site access and flight permission, and selects an eligible aircraft and robot.

Execution: the UAV records the aerial route while the robot observes the ground route; the console displays both progress streams on one event timeline. **Recovery:** the UAV returns to the cabinet for supervised exchange and the robot returns to its own charger. **Closure:** the operator compares findings, marks any maintenance issue and archives authorized evidence.

C3.2 Sensor alert verification

Trigger: a fixed sensor or site operator reports an anomaly. **Review:** the operator inspects source, confidence, location and current media reference. **Dispatch:** the operator may approve the UAV for an overview and S1/T1 for a close ground view, separately or in sequence. **Execution:** both assets report observations under the same event ID; the system displays conflicting observations rather than silently choosing one. **Closure:** the operator records a disposition and routes any physical intervention to the appropriate authorized person.

C3.3 Emergency situational assessment

Trigger: a site emergency team requests an overview. **Review:** the operator verifies the affected area, responder instructions, airspace and personnel safety. **Dispatch:** an approved aircraft task provides an overhead view; a robot may observe accessible ground areas without entering an unsafe zone. **Execution:** responders receive only the observations permitted by site policy and the operator can stop or redirect a task through the authorized process. **Closure:** the event includes actions, times, asset state and retained evidence references.

C3.4 Maintenance response

Trigger: a cabinet, aircraft or robot alarm inhibits a task. **Review:** the console identifies the affected asset, last confirmed physical state and recovery owner. **Dispatch:** a technician receives a service record; unaffected assets may continue only if their own permissions and separation remain valid. **Recovery:** the technician logs corrective action and affected-function checks; the supervisor records return to service. **Closure:** the fault and subsequent task outcome remain linked to the original event.

C3.5 Shared event with different viewpoints

An aircraft observation and a robot observation may disagree because of viewpoint, timing, occlusion or sensor health. The console shows each asset's source and timestamp. The operator reviews the difference and may request a second observation. The console retains both observations until an operator resolves the discrepancy. The final report distinguishes observed facts, operator conclusions and any unresolved condition.

C4. Site Console and Workflow

C4.1 Main menu

Menu	Customer view	Primary control
Mission Overview	Event map, queue, task timeline and approvals	Review, assign and close an event
Air & Ground	Separate cards for UAV, cabinet, S1 and T1	Choose an eligible asset and open its detailed status
Energy & Dock	Four-bay inventory, aircraft battery, robot battery and wireless dock	Review energy, charge and recovery availability
Alerts & Service	Active faults, owner, acknowledgement and maintenance task	Assign recovery and record return to service
Evidence & Data Policy	Local media reference, event summary, retention and export approvals	Review or authorize controlled access

Menu	Customer view	Primary control
Fleet & Sites	Asset serials, configuration, software and site profile	Manage approved configuration records

C4.2 Mission Overview layout

The left column lists events by priority and time. The center map shows the permitted task area, aircraft route, robot route and reserved cabinet/dock zones. The right column shows the selected event's approval, asset readiness and timeline. A bottom strip displays active alarms and the latest physical confirmations. The operator can switch from a common event to an asset-specific detail without losing the event ID or its approval context.

C4.3 Task timeline

Timeline entry	Required details
Event received	Source, time, location and initial severity
Review completed	Operator, observations and action decision
Clearance recorded	Site/flight/area permission and validity period
Task submitted	Request ID, asset, route/configuration version
Task accepted	Device acknowledgement and initial state
Action confirmed	Launch, walking, landing, exchange or actual charging feedback
Alarm or change	Code, affected asset, physical state and owner
Task closed	Outcome, evidence reference and final asset location

C4.4 Role and approval matrix

Role	Can review	Can dispatch	Can perform service	Can change policy
Observer	Permitted event summaries and assigned views	No	No	No
Operator	Events, routes, asset state and alarms	Approved routine tasks within site scope	No	No

Role	Can review	Can dispatch	Can perform service	Can change policy
Flight-responsible person	Aircraft route, airspace and flight status	Aircraft flight release and re-release after flight fault	Flight-system checks according to site authority	No
Supervisor	Full site operations and incident history	Authorize exceptions and return-to-service decisions	Review service result	Limited approved settings
Service technician	Affected asset diagnostics and service history	Controlled checks only	Yes, under isolation procedure	No general data policy
Administrator	Configuration and account records	No independent physical override	No	Users, retention and integration policy

The same person may hold more than one assigned role only if the customer's access policy permits it. No role grants permission to bypass a physical safety circuit, an aircraft flight check or a required legal approval.

C5. Connectivity, Local Data and Evidence

The local edge domain receives asset telemetry, events and authorized observation references. In the standard local-data configuration, raw continuous video is stored and viewed within the customer's local trust domain. The remote management view receives event summaries and selected metadata according to the configured policy. Selected event frames or clips may leave the local trust domain only under an authorized export policy with a recorded role, reason, time range and recipient. An event can be reviewed without uploading every frame of camera, UAV or robot video.

Data type	Local handling	Remote/export rule
Equipment telemetry	Current and historical asset state	Policy-selected summary and health metrics
Event summary	Shared event record with asset references	Export permitted by site policy
Continuous raw video	Stored or viewed in local trust domain	Continuous-feed export disabled in the standard local-data configuration
Selected event frame or clip	Local evidence reference and controlled selection	Explicit authorized export with audit record
Alarm and service log	Append event, acknowledgement and corrective action	Role-controlled access and audit

Data type	Local handling	Remote/export rule
User action	Record role, request, approval and result	Audit access according to customer policy

C5.1 Cloud-link loss

When the external management link is unavailable, the local controller retains the event queue, timestamps, device status and permitted local operating functions. Remote users see stale status; a command acknowledgement does not imply the device moved. Any action needing current external clearance or a human decision remains pending until that condition is available. On reconnection, the site compares request IDs, asset physical states and event sequence before synchronizing summaries.

C5.2 Device-link loss

Loss of aircraft telemetry invokes the aircraft's own flight-link behavior and prompts the flight team. The cabinet does not infer that the aircraft landed. Loss of robot control data causes its local controller to use the configured safe hold/stop behavior and the site console to mark its position stale. Loss of cabinet communication blocks new exchange requests until its physical positions and battery ledger have been reconciled.

C6. Cross-Asset Alarms and Escalation

Event	System-level consequence	Operator action
Cabinet lacks eligible module or free receiving bay	Aircraft return-to-exchange unavailable	Decide alternate recovery before aircraft battery reserve is consumed
Aircraft battery low during robot operation	Aircraft recovery gains priority in the landing zone	Reserve cabinet approach and reroute robot away from rotor zone
Robot enters cabinet exclusion zone	Conflicting ground path	Prevent new actions, use each asset's local safe hold/stop, clear people and confirm the physical state before restart
Robot wireless dock blocked	Ground robot replenishment unavailable	Assign parking or supervised recovery; do not use aircraft battery bay
Shared event has stale data	Operator decision lacks current status	Request fresh observation and preserve last known timestamp
Remote uplink unavailable	Off-site view stale	Use local console and preserve event queue

Event	System-level consequence	Operator action
Emergency stop actuated	Affected ground mechanism/robot held	Secure scene, inspect cause and record authorized reset

Alarms are classified as STOP, ACTION or ADVISORY. A STOP inhibits the affected action and requires a physical-state review. An ACTION requires an operator or service response before the next task. An ADVISORY records degradation and states which functions remain available. The alarm record shows the asset, exact condition, prevented action, last confirmed state, first response and recovery owner. One alarm on a robot does not automatically mark the aircraft safe or unsafe; each asset's local state is evaluated separately.

C7. Coordinated Shift and Incident Procedures

C7.1 Open a coordinated shift

Verify the site console clock, local link and account roles. Check the aircraft, cabinet, four module IDs, selected robot, robot dock and each active alarm. Inspect the aircraft approach and robot paths for conflict. Confirm operator, supervisor and service contacts. Record the shift opening state before accepting a new event.

C7.2 Reassign a task

If an asset becomes unavailable, open the event and record the reason. Compare the alternative asset's capability, current energy, route clearance and recovery plan. Seek the required new approval, then release a new task/request ID. Do not silently move an aircraft route onto a robot task or assume a robot can replace an elevated observation.

C7.3 Stop a coordinated response

Issue the appropriate controlled stop or return request to each asset separately. Watch for actual aircraft recovery, cabinet mechanism state and robot parking/charging feedback. If an asset cannot confirm a safe final state, preserve its fault and assign the responsible trained person. Close the shared event only after each participating asset has a recorded disposition.

C7.4 Preserve an incident record

Keep the original event ID, request IDs, route versions, approvals, alarm order, asset telemetry freshness and media references. Export only the material permitted by the customer data policy. Do not overwrite the first fault snapshot by repeatedly retrying a command. The incident report separates what a sensor recorded, what an operator decided and what a physical device confirmed.

C8. City Inspection, Detection and Authorized Response

C8.1 Operating scope and task authority

The city operating workflow joins scheduled inspection, site alarms, local visual analysis, aircraft observation, robot observation and maintenance dispatch under one event ID. The controller can collect observations, rank work and prepare an eligible task. It may release a routine task only within the site's recorded operating rules, route area, time window and assigned authority. Aircraft flight release follows the flight-responsible person's approved process and the aircraft's own preflight checks. A detection score or task suggestion never grants permission for a new flight area, entry into a restricted place, physical contact with a person, or a regulated response.

“Response” in this manual means verification, notification, a permitted observation mission, an approved warning function if fitted, a maintenance work order, or an action taken by the designated customer authority. The operator sees the proposed action, its source evidence and the permission that permits it. A person can cancel or stop an authorized task through the applicable device control path. Local aircraft, hangar and robot safeguards remain active throughout the common mission.

Workflow state	Entry and displayed evidence	Next decision or physical confirmation
DETECTED	Scheduled checkpoint, sensor alert or operator report; source and time attached	Triage source quality and location
TRIAGED	Severity, affected area, people and asset status reviewed	Dismiss with reason, request a second view or open a task proposal
VERIFIED	Independent view, operator review or field report supports the finding; disagreement remains visible	Select the responsible person and response class
TASK PROPOSED	Candidate air/ground route, energy budget, zone and asset readiness displayed	Check site policy, flight clearance and local guards
CLEARED	Authorized person or valid site rule, route version and time window recorded	Send one uniquely identified task request
ACTIVE	Device accepted request and then reported actual movement or flight	Monitor progress, freshness, energy and exclusion zones
RESPONSE PENDING	Observation complete; a work order, emergency team or other authority owns the next action	Receive an explicit disposition from that owner

Workflow state	Entry and displayed evidence	Next decision or physical confirmation
RESOLVED	Action and any required verification pass are recorded	Confirm every participating asset recovered safely
CLOSED	Event report has outcome, evidence references, approvals and final asset states	Preserve for audit and trend reporting

An event may return from VERIFIED to TRIAGED if later evidence contradicts the first interpretation. A task may move from ACTIVE to HOLD, RETURN or ABORT according to the responsible asset's own control procedure. The console never turns a stale last-known position into a current observation. If an external authority has not responded, the event stays RESPONSE PENDING and shows its owner and age; closing the UAV sortie alone does not close the city incident.

C8.2 Detection, verification and escalation rules

A local model may identify a person, vehicle, animal, boundary crossing, obstruction or visible equipment anomaly when the fitted camera, model package and site policy support that class. The result is an observation with source, time, location, class and confidence. It is not, by itself, a confirmed identity, legal finding or instruction to intervene. The operator can compare a fixed view, aircraft view and robot view using their capture times and camera directions. Poor light, dust, rain, occlusion, image blur or a blocked sensor lowers the evidence quality and can require a new view or manual field inspection.

Decision level	Permitted system action	Human or authority action
Routine scheduled inspection	Build route and checkpoint list; check asset, energy and zone readiness	Approve or release under the recorded site and flight procedure
New anomaly with adequate source quality	Create an event, group related observations and suggest a verification viewpoint	Review classification, location, affected people and task proposal
Conflicting, low-quality or stale observations	Keep alternatives visible and request a fresh view	Decide whether to inspect again, assign ground staff or leave unresolved
Public-safety or regulated event	Preserve evidence, notify the configured customer role and hold any gated action	Designated authority decides any enforcement or other regulated response
Immediate equipment hazard	Stop or inhibit the affected equipment action through its local safety path	Qualified personnel make the area safe and release equipment after checks

Each escalation shows the observation that caused it, the rule or person that selected the next step, and the time the receiving owner acknowledged it. A request for a second viewpoint must specify the question to answer; repeated flights without a new purpose consume energy and can obscure the original evidence

sequence. The site supervisor sets local severity, acknowledgement and escalation windows in the customer policy record. A missing policy value is displayed as unconfigured and does not become a guessed deadline.

C8.3 Asset selection and route handoff

For each candidate task the dispatcher compares observation geometry, safe access, estimated mission energy, current SOC/SOH, communications, weather, people and recovery location. Aerial overview is selected for roofs, upper façades and wide outdoor context. A ground robot is selected for accessible close views and approved manipulation using its installed end effector. Both can operate under the same event only when their routes, recovery paths and exclusion zones do not conflict. A robot is never sent into the cabinet roof or rotor area to continue a task while the aircraft is being prepared, launched or recovered.

Handoff is explicit: the aircraft report gives a georeferenced observation and uncertainty; the operator selects a ground inspection point; the robot receives a separate route and task ID that refer to the parent event. The robot confirms its own arrival and observation. If the location is inaccessible or the two observations disagree, the record shows both facts and the operator chooses another safe view. A media crop or AI label cannot substitute for a robot's physical arrival, nor can a robot close-up establish a condition on an inaccessible roof.

C9. City Operating Scenario Cards

C9.1 Municipal asset defect inspection

This procedure applies to a site-authorized route covering visible municipal assets such as cabinet doors, lighting structures, drainage inlets and external equipment surfaces. An asset register supplies the asset ID and inspection points. The fitted observation payload determines which visual or thermal findings are available. Thermal findings require an installed thermal sensor; RGB imagery supports visual findings.

Stage	Input and operating action	Output, owner and fallback
Plan	Select asset IDs, checkpoint views, access window and priority; check route permissions	Approved route version and responsible operator; inaccessible points remain open
Aerial survey	Release eligible aircraft after flight checks; record each visible upper structure and image reference	Aircraft observation with asset ID, viewpoint and time; return or abort on energy/link condition
Ground verification	Assign S1 or T1 to an accessible point; inspect doors, labels, leaks or surface condition from a safe route	Robot observation and arrival confirmation; field staff take over if clearance or footing is unsuitable
Triage	Compare both observations with asset history; separate confirmed defect from uncertain visual cue	Defect class, severity, evidence references and reviewer; request another view when needed

Stage	Input and operating action	Output, owner and fallback
Work order	Assign a technician, location, access requirement and affected service	Work-order ID and acknowledgement time; hold the issue open if no owner accepts
Return and close	Recover aircraft and robot independently; technician records repair and affected-function check	Final asset states, service result and reinspection record; unresolved defect remains open

The defect record includes the asset ID, component or surface, location, image viewpoint, visual description, observed dimension only when a calibrated measurement exists, and any effect on service. A model suggestion may group similar cases but the technician records the physical cause. If a robot is asked to handle an object, the fitted tool, object mass, reach and human clearance follow the robot task limits in Part IV.

C9.2 Perimeter anomaly and person-search support

This procedure supports detection and observation in an approved area. It does not establish personal identity or authorize pursuit, detention or force. A site event may begin with a fixed-camera boundary observation, a person/vehicle/animal class, an operator report or a request from a competent response team. If the event concerns a missing person, the responding organization defines the search area, privacy controls and coordination lead before any aircraft or robot task is released.

Stage	Input and operating action	Output, owner and fallback
Locate	Record source camera, boundary segment, time, track reference, class and confidence	Event map point or bounded area with location uncertainty; poor source quality is flagged
Review	Operator checks media, the current site state, pedestrian access and task purpose	Confirmed need for observation or documented dismissal; uncertain class is not treated as identity
Air task	Flight-responsible person reviews airspace, weather, route, people and return plan	Aircraft overview and timestamped observations; no launch if release gates fail
Ground task	Select a safe, authorized robot route to a separate viewpoint	Robot arrival and close observation; pause for people, unstable footing or link loss
Handoff	Show both views, timestamps, confidence limits and map location to the designated response lead	Acknowledged handoff and response decision; no automated enforcement command
Closure	Record last known area, outcome, evidence handling and both asset recovery states	Closed or still-open case with owner, disposition and follow-up time

The common timeline must distinguish the first detection time from a later aircraft or robot sighting. It must show when a target was lost from view and must not join unrelated tracks into a continuous path without evidence. If a person is found in a hazardous location, the responding team directs the next action; the robot may provide a permitted view but does not substitute for trained responders.

C9.3 Flood, fire or hazardous-area assessment

The incident commander defines the assessment area and operational objective. Local weather, airspace, smoke, heat, wind, unstable ground and public access can disqualify a route even when a device is powered and connected. The system reports what its fitted sensors observe; it does not infer gas composition, depth or temperature without the corresponding measurement source.

Stage	Input and operating action	Output, owner and fallback
Request	Incident location, hazard class, command owner, permitted observation corridor	Time-stamped event and area boundary; incomplete authority holds dispatch
Readiness	Check aircraft weather/energy/link/recovery and robot terrain/personnel exclusion	Eligible asset set and reasons for inhibited assets
Aerial assessment	Observe extent, access routes or visible change from a cleared flight route	Map overlay and source media references; return before configured energy limit
Ground assessment	Observe only accessible, cleared ground points and equipment condition	Ground-level report and any blocked path; no robot entry beyond its operating limits
Command handoff	Send location, observation times, uncertainty and selected evidence under data policy	Acknowledgement from response owner and next inspection request, if any
Reassessment	Repeat a permitted checkpoint after a material change and compare time-aligned evidence	Trend with source and interval; a missing observation remains missing
Stand-down	Confirm aircraft landing/capture, robot parking or charging, and hangar state	All participating asset dispositions and incident report

An aircraft or robot approaching its energy or link limit is recovered under its own contingency procedure; the common incident remains open for ground teams. Visual evidence supports situational awareness, while evacuation, access control and emergency intervention remain with the customer's appointed command authority.

C10. Observation Data and Operator Displays

C10.1 Common observation record

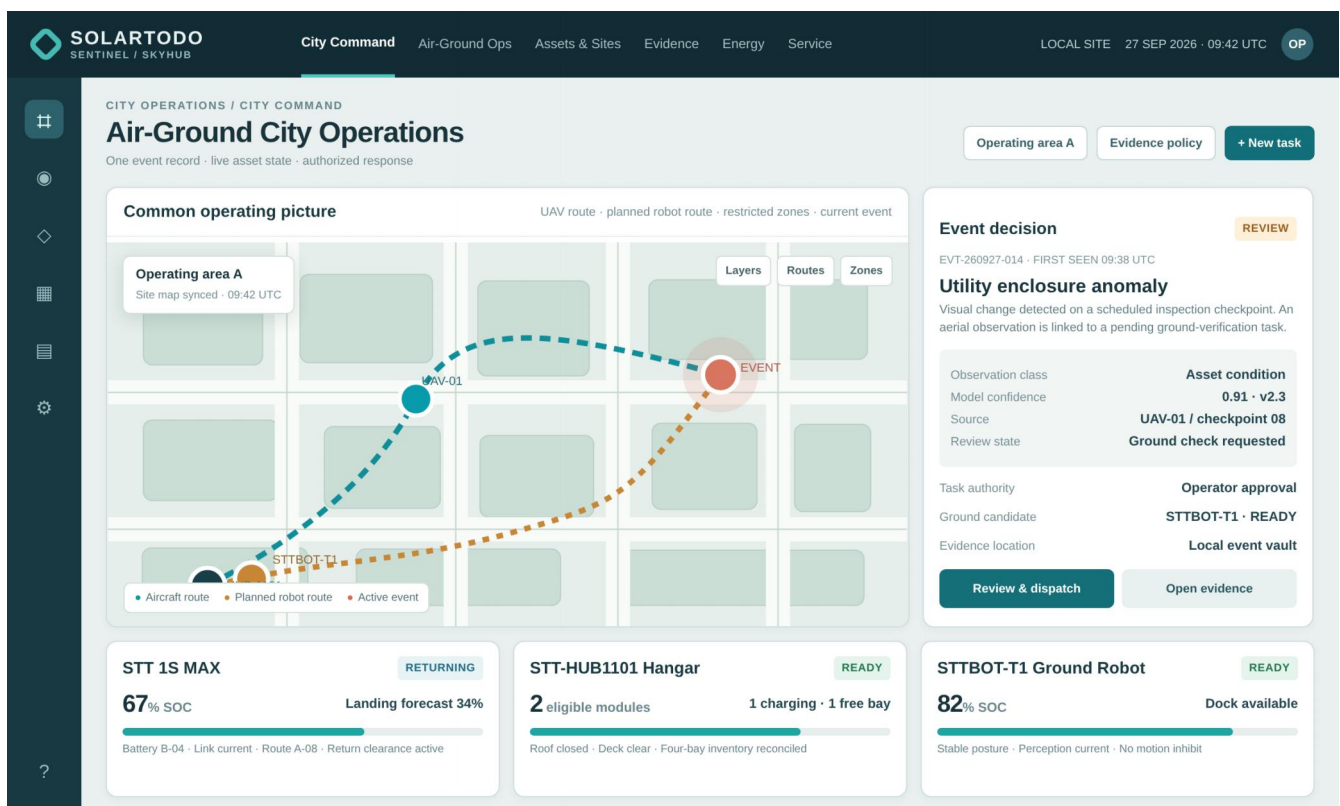
Every machine observation and operator finding is linked to a stable event ID. The record separates an image-level detection from the site-level event, so several detections can support one incident without counting as several incidents. Times are stored with their time zone and source-clock status. The console shows capture time, receipt time and the age of the last update. A configured freshness limit is applied per source; when the age exceeds it, the card reads STALE and control decisions requiring current data remain unavailable.

Field	Display format and meaning	Required interpretation
Event ID / observation ID	Stable identifiers	Preserve links across air, ground, alarm and work order records
Source asset / sensor ID	Aircraft, robot or site sensor identity	Distinguish independent viewpoints and installed capabilities
Capture time / received time	Time with zone and clock-sync state	Expose delayed transmission or an unsynchronized source
Location / uncertainty	Map point or area, coordinate reference and accuracy/uncertainty	Do not show an uncertain point as an exact location
Model package / version	Installed model and configuration identity	Allow reviewer to reproduce which classifier generated a label
Detected class / track ID	Class from the enabled site taxonomy; local track reference	A class is not a verified identity or an action authorization
Model confidence	Score on 0–1 scale, with source model named	A score is not a measured field accuracy or event probability
Region / viewpoint	Image region, camera pose or field-of-view reference	Help compare observations from different angles
Quality flags	Blur, occlusion, low light, weather or sensor obstruction	Show why review or another observation may be required
Evidence reference	Local frame/clip ID and integrity reference	Keep raw continuous media under the local data policy
Review result	Confirmed, dismissed, uncertain or needs inspection; reviewer and time	Preserve human interpretation separately from model output
Task and response link	Task IDs, authorized owner, disposition and work-order ID	Trace what followed from the observation

A change to a model package or threshold is recorded with its version, effective time and authorized owner. Trend charts group observations by the model and site configuration in force at the time. The operator cannot compare confidence values from two different model versions as if they shared a calibrated scale. Confirmed and dismissed findings are available for supervised quality review; a claim of detection precision requires a labeled review set and an explicit calculation period.

C10.2 Screen 1 — City command map and event queue

The command view places the permitted operating area and current incident on a map. Separate layers show the aircraft route and position, robot route and position, cabinet approach zone, robot charging area, restricted areas and the last confirmed observation locations. A task queue alongside the map lists ownership and the next required decision. Selecting an event keeps its original ID visible while opening the observation and asset details.



City Operations interface: route, asset and decision state in one view.

Display field	Unit or state	Decision supported
Active events by severity and owner	Count, state and age	Select an event that needs review or escalation
Event point or area	Coordinate/area with uncertainty	Distinguish a known asset from an approximate sighting
Air and ground route versions	Route ID, checkpoints and progress %	Check that each asset follows the approved path

Display field	Unit or state	Decision supported
Aircraft/robot last location	Coordinate, time and FRESH/STALE	Avoid dispatch or rerouting from an outdated position
Exclusion and recovery zones	Map area and occupancy state	Keep people and the robot clear of aircraft operations
Pending approval	Role, request ID and time	Identify who can release the next action
Latest physical confirmation	Airborne/landed/captured or walking/parked/charging	Separate request acceptance from physical outcome

The map may display a last-known trail for context, but the trail ends at the last actual update. A connection loss cannot make a marker continue moving by prediction without a clearly separate predicted-state label. A task with a stale source remains in the queue for review rather than disappearing from the city picture.

C10.3 Screen 2 — Detection and evidence review

The review screen presents the original observation, any permitted selected frame, source quality, model result and independent air/ground views in time order. Review controls record CONFIRM, DISMISS, REQUEST NEW VIEW or ESCALATE with reason and operator identity. A regulated or public-safety action uses the customer's designated authorization path; the screen cannot turn CONFIRM into an automatic physical response.

Display field	Unit or state	Decision supported
Source and capture/receive time	Asset ID; timestamp; age in seconds/minutes	Identify delayed or old evidence
Class, model ID/version and score	Taxonomy label; version; 0–1	Judge whether the model suggestion matches the image
Image region and track continuity	Region reference; first/last seen time	Check what was detected and where a track was lost
Geolocation and uncertainty	Coordinate/area; accuracy if available	Select a safe verification viewpoint
Quality and sensor-health flags	Clear/degraded/blocked	Decide whether a second view is necessary
Air/ground comparison	Side-by-side source/time and review status	Preserve agreement, disagreement or unknown result
Evidence and export status	Local reference; held/approved/exported	Apply retention and data-access policy

The display never substitutes a model-generated caption for the underlying source reference. Continuous raw video is viewed or stored in the local trust domain. A selected frame or clip leaves that domain only with the recorded export authorization described in C5.

C10.4 Screen 3 — Air-ground readiness and energy

This view gives one row per device and one row per aircraft battery module. Readiness is a result of explicit gates, not a single green lamp: the operator can open the reason an aircraft, cabinet, battery, robot or dock is unavailable. The flight-energy panel shows both the planned and live prediction for landing SOC, with the calculation inputs and timestamp visible.

Display field	Unit or state	Decision supported
Aircraft flight state, route and controller health	Mode, route ID, current alarm	Decide launch, monitoring or return under flight procedure
Aircraft battery ID, SOC, SOH, cell/temperature alarm	ID, %, %, °C and status	Check eligibility and remaining energy
Predicted landing SOC and planned energy	%, Wh, input age	Detect a route that will cross the configured landing floor
Link and navigation quality	Current state and last update	Distinguish safe telemetry from stale command status
Four hangar bay states and receiving position	Bay ID, empty/occupied, module ID	Confirm the receiving bay and replacement availability
Each module charge and eligibility	SOC %, SOH %, °C, actual W, fault	Know which module is ready, charging or isolated
Roof, deck, retention and transfer state	Physical-confirmed state	Keep flight release separate from ground mechanism state
Robot ID, model, task, posture and safety state	ID, state, alarm, update age	Check ground route and balance readiness
Robot battery and wireless dock	SOC %, BMS state, alignment, actual W	Decide ground return and charging availability

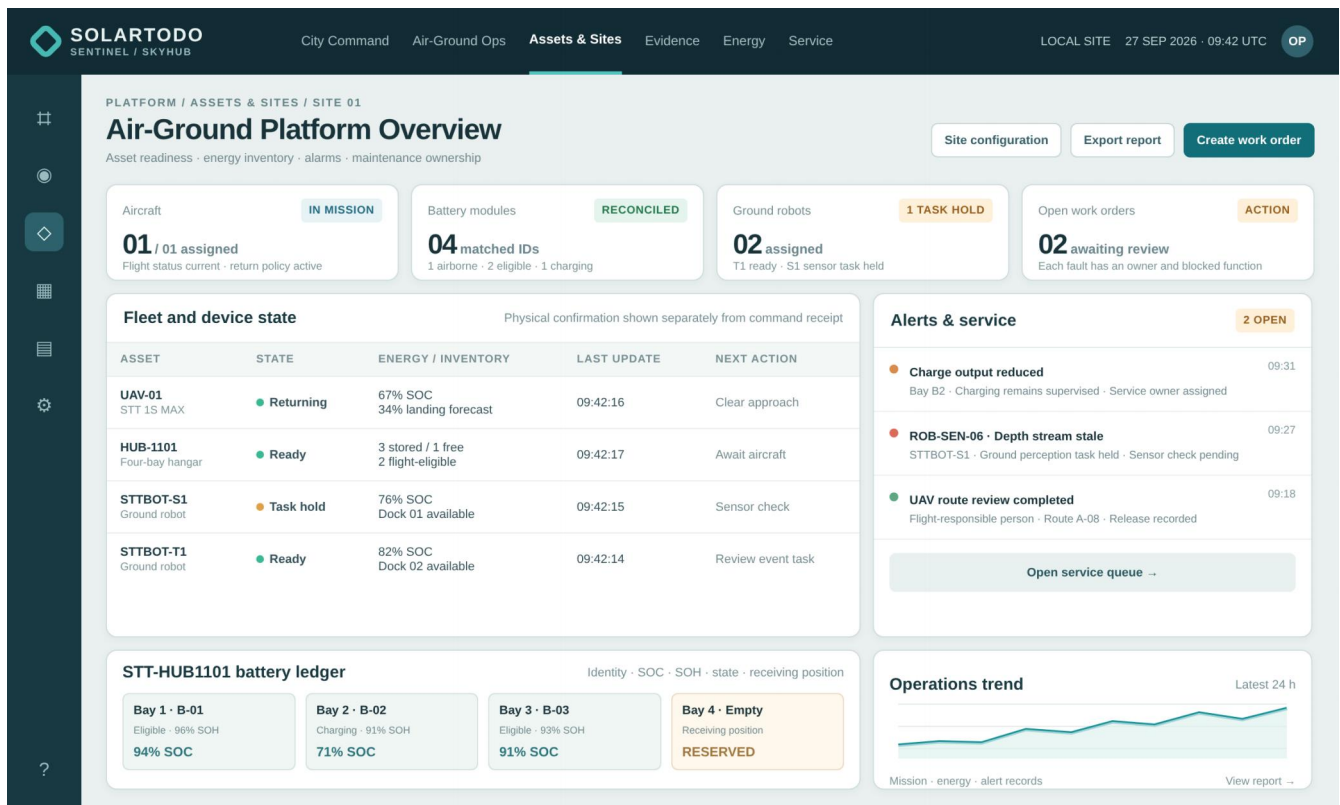
An aircraft with a planned route still needs a current module, flight checks and an available recovery option. A robot with an adequate battery still needs a clear path and local motion checks. An empty cabinet bay is not a charged replacement; the display identifies the receiving position and the eligible stored module separately.

C10.5 Screen 4 — Alerts, service and outcome

The operations record pairs the alert queue with work orders, recurrence trends and return-to-service decisions. It exposes blocked functions and the physical state last confirmed, so an acknowledgement cannot be mistaken for a repair. Each work order stays linked to the event, affected device, battery identity when relevant and the technician's functional check.

Display field	Unit or state	Decision supported
Alarm ID, class and first occurrence	STOP/ACTION/ADVISORY; timestamp	Prioritize a hazard or degraded function
Affected asset, blocked action and physical state	Device ID; inhibited function; confirmed state	Avoid repeating a command into an unknown mechanism
Acknowledgement, owner and elapsed time	Person/role; timestamp; duration	Escalate an unowned or aging alarm
Work-order status	Open/assigned/repair/check/ released	Track corrective action to a verified result
Battery, joint, mechanism or charger trend	SOC/SOH, temperature, fault count, actual W as relevant	Detect recurrent degradation and schedule service
Affected-function test and release	Result; technician/supervisor; time	Restore only the functions that passed the check
Incident disposition	Confirmed, dismissed, unresolved or transferred	Produce an honest event outcome and follow-up owner

The page offers filters by site, asset, severity, time interval and owner. Exported reports carry the filter interval and data completeness statement. Service history is preserved when an asset is replaced or its software revision changes, allowing a trend to be interpreted against the actual configuration.



Platform Overview interface: battery inventory, alarms and service ownership.

C11. Operating Metrics and Report Definitions

Metrics use event and physical-confirmation records, not command acknowledgements alone. Every report shows site, start/end time, time zone, included assets, source freshness and the number of records lacking a required timestamp or disposition. Where a denominator is zero, the value is shown as “— (no eligible records)” rather than 0% or 100%. Late-arriving data can revise a report, with its revision time displayed.

Metric	Definition	Data needed and handling of incomplete records
Inspection checkpoint completion	Physically confirmed checkpoints ÷ planned eligible checkpoints × 100%	Keep blocked, skipped and unverified points as separate counts; do not count a route command as a visited point
Mission completion	Dispatched tasks closed with a successful disposition for every assigned asset ÷ dispatched tasks × 100%	Failed, aborted and unresolved tasks remain in the denominator and are listed separately; a returned aircraft with an unresolved robot is not complete

Metric	Definition	Data needed and handling of incomplete records
Alert review coverage	Alerts with confirmed, dismissed or unresolved-with-owner review $\div$ alerts requiring review $\times 100\%$	Unacknowledged alerts remain in the denominator; show their count
Confirmed finding proportion	Operator-confirmed findings $\div$ findings with a completed human review $\times 100\%$	This is a review outcome ratio, not model precision; excluded/no-review count is shown
Time to first acknowledgement	First owner acknowledgement minus event origin time	Origin is first detection for a sensed event, or opening time for a scheduled/manual event; report origin type and missing pairs
Time to verified response	First qualified field or operator verification minus event origin time	Use the same event-origin rule; do not use a proposed task or request acceptance as verification
Dispatch delay	Device task acceptance minus authorized task submission	Split air and ground; report failed or timed-out requests separately
Asset dispatch availability	Time an asset met its defined release gates $\div$ planned operating time $\times 100\%$	Exclude approved out-of-service windows only if report policy says so; show exclusion time
Exchange physical completion	Exchanges confirmed through the final physical handover $\div$ initiated exchanges $\times 100\%$	A timed-out exchange counts as unresolved until actual state is reconciled
Robot charge-session completion	Sessions with BMS and actual-transfer completion $\div$ sessions initiated $\times 100\%$	Separate alignment refusal, electrical stop and operator stop
Maintenance closure time	Verified return-to-service time minus work-order creation time	Report by severity; leave open orders aging in a separate backlog chart

Daily and monthly operations reports list event count by category, confirmed/dismissed/uncertain outcomes, checkpoint coverage, device availability, battery cycles and SOH, actual charge energy, active fault count, open work orders by age and the assets awaiting release. A chart can show changes over time, but the report never fills gaps with interpolated successful missions. Model quality review compares human-labeled cases for a named model version and site period; the console does not claim sensitivity or false-alarm rate from confidence scores alone.

C12. Energy-Aware Dispatch and Continuity

C12.1 Aircraft mission budget

The STT 1S MAX aircraft carries a 149.9 Wh module. Its maximum forward-flight time is 54 minutes under the stated windless full-battery condition, while maximum hover time is 47 minutes. The site dispatch threshold is 90% SOC and the configured return policy preserves landing energy. Route, climb, wind, manoeuvre, observation load and battery health affect the available mission time. The aircraft controller's active limits and live telemetry govern the return decision.

Mission budget item	Planning entry	Live check
Dispatch energy	Module ID, SOC, SOH, temperature and eligible Wh	Re-read immediately before release
Outbound leg	Route distance, planned time and energy	Compare actual time, power and position
Observation	Checkpoints, dwell time and payload use	Stop or shorten observation when reserve shrinks
Return and approach	Route to the available recovery point, landing time and energy	Recalculate from current position and cabinet state
Contingency	Site and flight-controller margin for wind, deviation and alternate recovery	Keep the configured landing SOC floor intact

The planning condition is $\text{outbound Wh} + \text{observation Wh} + \text{return Wh} + \text{approach Wh} + \text{contingency Wh} \leq \text{energy available above the configured landing SOC floor}$. At any point in flight, the console shows $\text{predicted landing SOC} = \text{current SOC} - \text{predicted remaining-route-and-approach energy} \div \text{full-charge usable battery energy} \times 100$, using the BMS full-charge usable capacity for the installed pack and showing telemetry age and assumptions. Contingency and the configured landing floor are checked separately. If the predicted landing SOC crosses that floor, the flight team follows the aircraft's return or alternate-recovery procedure. The return trigger occurs early enough to complete the return and landing; reaching 20% SOC at a distant observation point is not a valid plan. When flight power, route speed or wind is unknown, the console marks the estimate unavailable and the operator uses the aircraft's conservative flight procedure.

C12.2 Exchange inventory and ground continuity

The standard delivery contains one aircraft and four matched aircraft battery modules: one in the aircraft, three in the four-bay hangar and one receiving position kept free for the returning module. The operator sees module ID, SOC, SOH, temperature, charge state, bay and eligibility. An occupied bay does not imply a

ready module. Before a repeat sortie, the system confirms landing, retention, propulsion inhibit, exchange completion, the new module's identity, aircraft restart checks and a new flight release. The robot's 200 W wireless dock is an independent charging path; its battery cannot be inserted into an aircraft bay.

Mission scheduling considers the next eligible module, actual charge progress, aircraft turnaround, operator availability and the next route's energy budget. If no replacement is eligible, the planner offers a later departure or a different authorized observation method. The single-aircraft configuration cannot provide simultaneous aircraft coverage. Any multi-site relay or continuous-air-presence service requires its own configured aircraft, cabinet, route, charging and flight-authority plan; the local four-module inventory alone does not establish that service.

C12.3 Priorities during a shared incident

When an aircraft must recover while the robot is active, reserve the cabinet approach and roof/rotor exclusion area first. Pause or reroute the robot through its own safe motion path and keep people clear. An urgent ground finding does not justify delaying a low-energy aircraft return. If the cabinet is unavailable, the flight team chooses the previously approved alternate recovery point and the console keeps the event and aircraft state open until actual landing is confirmed. A failed charge or exchange affects future sortie availability, not the evidence already collected by a completed task.

C13. Coordinated Operations and Maintenance Handoff

C13.1 Shift summary and exception review

At shift end, the operator reconciles each event with its aircraft task, cabinet exchange, robot task, alarms, evidence references and work orders. The handoff shows which assets are available, held, charging, isolated or awaiting inspection. For each open event it records the last confirmed physical state, current owner, next decision and due time under the customer's policy. If a link is stale, the handoff names the last source update and assigns a person to verify the physical state before another command.

Handoff item	Minimum record	Next owner action
Open city event	Event ID, location, severity, evidence state and authority owner	Review or escalate within site policy
Active or interrupted flight	Aircraft/battery IDs, route, last telemetry, return point and flight lead	Confirm actual landing and flight disposition
Cabinet exchange or charge	Cabinet/bay/module IDs, last confirmed stage, alarm and retained load	Reconcile physical inventory before restart
Robot field task	Robot ID/model, location, posture, carried item, battery and safety state	Confirm safe park, recovery or authorized handover

Handoff item	Minimum record	Next owner action
Data and model exception	Source, version, clock/freshness issue or disputed classification	Preserve source evidence and assign review
Work order	Affected asset, blocked function, technician, check and release owner	Complete repair and affected-function check

C13.2 Trend-led maintenance decisions

Operations review the same fields used for dispatch: aircraft voltage sag and battery health, cabinet motion and latch alarms, module charge power, robot joint faults and fall history, dock alignment, sensor obstruction, link freshness and model-review outcomes. A trend triggers investigation when it deviates from that site's accepted baseline or repeats under the configured maintenance rule. Service intervals follow site-specific trends and the maintenance policy; each report includes source IDs, dates and the affected configuration. Service personnel isolate a hazardous asset, record the cause and perform the checks in Part VI before supervisor release. A flight-related repair also requires the flight-responsible person's release.

C13.3 Customer report package

For an agreed reporting interval the site can provide an event summary, checkpoint completion, alert-review outcomes, asset and energy availability, battery ledger, work-order backlog, corrective actions and approved evidence references. The report identifies its interval, site configuration, data completeness, model versions and approval/export record. It separates **observed, operator-reviewed, physically confirmed** and **pending** items. This lets the customer evaluate the full air-ground service without treating a command receipt, model suggestion or closed aircraft sortie as proof that an incident was resolved.

PART VI

Site Operation and Records

Checklists, fault ownership, maintenance planning and customer handover forms.



F1. Site Operating Rules

The site owner appoints an operator for routine missions, a supervisor for fault release, a qualified service technician for mechanical/electrical intervention and a flight-responsible person for aircraft operations. A single mission may involve several roles; the event record names who approved each action. Keep current site access, flight and privacy permissions with the configuration sheet. The equipment's display does not replace the site operating authority.

F1.1 Controlled areas

Area	Normal access rule	When active
Aircraft approach/departure	Clear of people and loose items	From ground flight preparation or roof opening, and before inbound recovery, until confirmed departure or landing with propulsion inhibited
Cabinet roof travel	No reach-in or obstruction	Whenever roof motion is permitted
Cabinet deck and battery mechanism	Closed access and monitored interlocks	During lowering, exchange and recovery
Robot walking route	Segregate from unbriefed pedestrians	Walking or teleoperation task
Robot wireless dock	Keep alignment surface free of metal/debris	Docking and charging
Electrical/service zone	Authorized and isolated access	Inspection or corrective maintenance

F1.2 Start-of-day release sheet

Item	Pass criterion	Result / initials
Site and weather	Aircraft and robot routes remain within permitted conditions	_____
Cabinet exterior	Roof, seals and access area free of damage and debris	_____
Aircraft	Identity, propellers, landing gear, latch and payload checked	_____
Battery inventory	Four IDs accounted for; one receiving bay free; eligible replacement present	_____

Item	Pass criterion	Result / initials
Hangar self-check	READY and no blocking alarm	_____
Robot	Correct S1/T1 model, stable posture, sensor and joint checks clear	_____
Robot charging area	Pad clear, alignment and energy state valid	_____
Communications	Local status current; remote freshness visible	_____
Operator authority	Flight/site permissions and roles recorded	_____

If a row fails, record the asset and condition in the event/maintenance log and prevent the affected mission. A sign-off is a record of the observed condition at that time; it is not a substitute for the controller's live interlocks.

F2. Preventive Maintenance Program

Interval	UAV	STT-HUB1101	STTBOT-S1 / T1	Console and records
Each shift	Frame, propellers, battery latch, payload and landing gear	Roof/deck area, bays, alarms, empty receiving bay	Feet, joints, battery, sensors, dock surface	Clock, link, active event and permissions
Weekly	Connector wear, aircraft event trends, sensor windows	Seals, cameras, drainage, contacts, charging trends	Foot wear, joint sounds, charger alignment, sensor windows	Review recurrent alarms and unresolved actions
Monthly	Battery health and configuration review	Motion history, latch feedback, charging allocation and log capacity	Battery and charge-power trends; sensor calibration status	User roles, retention and backup policy review
After intervention	Affected flight and battery checks	Affected interlocks, exchange path and self-check	Balance, joint, sensor and dock functional checks	Record change, training and return-to-service decision

F2.1 Cabinet service focus

Track roof opening/closing position consistency, deck travel, aircraft retention, transfer-tool position, bay identity, charging stop feedback, emergency stop and access circuit. Inspect surfaces and seals without entering while motion is enabled. A battery stuck in the tool or a raised deck is treated as a retained load. The technician secures that condition before physical access and records the actual location of each module before restart.

F2.2 Aircraft service focus

Track battery cycles and health, abnormal voltage sag, flight-controller events, vibration, propeller damage, landing impacts and payload mounting. A change to mass, center of gravity, propeller class, sensor or battery interface triggers a configuration review and affected flight checks. The aircraft's return reserve is updated only through the flight operations process.

F2.3 Robot service focus

Track falls, joint temperature/fault frequency, foot and pad wear, sensor obstruction, BMS events, charge alignment and power-transfer trends. A robot that has fallen or struck an obstacle is not returned to a mission on an alarm acknowledgement alone. Inspect balance-critical parts and run an appropriate walking check in a clear area before release.

F2.4 Battery care

Aircraft batteries and robot batteries are different products with different charging systems. Record each battery ID, current location, SOC, SOH, temperature, cycle count and service decision. Isolate a module with swelling, impact damage, liquid ingress, contact damage or unexpected heating according to the site's battery incident procedure. Do not move a module whose charging-stop feedback is unresolved. Keep charging and storage areas within the battery's permitted temperature and ventilation conditions.

F3. Incident Response Cards

F3.1 Immediate hazard at cabinet

Recognize: person or obstruction in roof/deck/tool path, uncontrolled motion, access interlock fault, held battery or visible electrical abnormality. **Act:** use the local emergency stop when immediate hazardous motion must cease; keep personnel clear and contact the site supervisor and service technician. **Record:** time, cabinet state, aircraft ID, battery ID and last confirmed stage. **Recover:** inspect retained loads and electrical state; resolve the cause; test the affected safety function; run full self-check before new exchange.

F3.2 Aircraft fault in the air

Recognize: flight-control, navigation, battery, link or route condition that changes the safe flight plan. **Act:** the trained flight team applies the aircraft's approved contingency. Confirm the cabinet's actual recovery availability without assuming it is ready from an old screen. Keep other assets clear of the recovery area. **Record:** route, time, battery and link state. **Recover:** inspect aircraft and battery after landing; assign flight release separately from hangar release.

F3.3 Robot instability or contact incident

Recognize: fall, uncontrolled joint motion, collision, dropped object or a person entering the route. **Act:** stop or hold the task using the local safety path; clear the area and secure any carried load. **Record:** robot ID, pose, object, battery state, last command and sensor condition. **Recover:** qualified inspection of structure, joints, sensors and battery, then controlled balance and motion check.

F3.4 Battery thermal or charging incident

Recognize: abnormal temperature, odor, swelling, smoke, charger mismatch, foreign-object alarm or charge stop not confirmed. **Act:** stop routine tasks and charging as the system permits, clear people from the area and follow the site's emergency response plan. Do not handle a hot or damaged module to complete a mission. **Record:** battery ID, bay/dock, temperature trend, current state and alarm. **Recover:** qualified inspection and disposition; affected channel functional check before return to service.

F3.5 Loss of local or remote connectivity

Recognize: stale timestamps, lost controller session or missing device telemetry. **Act:** do not repeat a movement or flight command until its actual state is known. Use local indicators and the asset's approved failsafe/hold procedure. **Record:** last request ID, last confirmed position and time. **Recover:** reconcile physical states and inventory, restore link, run affected self-check and submit a new request if still needed.

F4. Maintenance Work Order and Return to Service

Work-order field	Entry
Site / asset / serial	_____
Date and responsible person	_____
Event and alarm IDs	_____
Initial physical state and retained loads	_____
Battery IDs and electrical state	_____

Work-order field	Entry
Cause found and corrective action	_____
Parts/configuration/software affected	_____
Affected-function check and result	_____
Full self-check and result	_____
Supervisor release and time	_____
Flight-responsible release after aircraft fault, if applicable	_____

The work order remains linked to the original event. The technician records the physical cause and actual test performed; the supervisor records the decision to restore routine operation. If a function has not been checked, the affected asset remains unavailable for that function.

F5. Customer Delivery and Configuration Sheet

F5.1 Delivered assets

Asset	Model / serial	Quantity / configuration	Site location
Exchange aircraft	_____	One / payload: _____	_____
Battery exchange hangar	STT-HUB1101 / _____	One / four-bay independent	_____
Matched aircraft battery modules	IDs: _____	Four total, including aircraft module	_____
Ground robot	STTBOT-S1 / _____	Quantity: _; tool: _	_____
Ground robot	STTBOT-T1 / _____	Quantity: _; tool: _	_____
Robot wireless charging station	ID: _____	200 W per supplied robot charging position	_____
Local console / edge controller	ID: _____	Software and policy revision: _____	_____

F5.2 Aircraft and cabinet configuration

Controlled field	Delivered value
Aircraft takeoff mass with installed payload	_____ kg
Payload identity, mass and power	_____
Aircraft center-of-gravity and landing interface record	_____
Flight-control software/configuration revision	_____
Approved route area and return reserve	_____
Aircraft battery module revision and four IDs	_____
Fitted module outside dimensions, contact/latch drawing and charge-profile revision	_____
Fitted module discharge/charge ratings and 20–90% condition record	_____
Cabinet serial, software, safety configuration	_____
Emergency-stop/access-interlock function-check record	_____
Battery bay assignment and receiving-bay rule	_____
Site supply circuit and network identity	_____

F5.3 Robot configuration

Controlled field	S1 if supplied	T1 if supplied
Robot serial / software revision	_____	_____
Standing outside width × depth and folded envelope	_____ mm	_____ mm
Installed battery ID, nominal voltage, Ah and Wh	_____	_____
End effector, grip type and permitted task load	_____	_____
Joint-limit and mobility-profile revision	_____	_____

Controlled field	S1 if supplied	T1 if supplied
Approved walking area, slope, step and stopping zone	_____	_____
Sensing, localization and observation configuration	_____	_____
Wireless dock identity and power policy	_____	_____
Emergency-stop and local balance-check record	_____	_____
Audio and remote-operation options	_____	_____
Authorized operator and teleoperation roles	_____	_____

F5.4 Handover checks

Check	Record
Asset identities, quantities and configuration match	Pass / action: _____
Cabinet roof, deck, capture and four-bay inventory	Pass / action: _____
Battery eligibility, charge start/stop and exchange state	Pass / action: _____
Aircraft preflight, landing, retention and handover interface	Pass / action: _____
Flight-responsible person and aircraft release record	Name/time: _____
Robot balance, route, sensing and 200 W charging status	Pass / action: _____
Emergency-stop and access responses	Pass / action: _____
Local console, alarms, event record and data policy	Pass / action: _____
Operator, supervisor, flight and service training	Names/date: _____
Open items and owner	_____
Customer and SOLARTODO signatures	_____

F6. Records, Retention and Training

Keep the signed configuration and handover sheet with the current manual. The local cabinet event log retains at least 90 days of event history. The site owner sets media, export and backup retention according to its policy. A complete event contains the authorizing person, device and module IDs, request and physical completion, alarms, intervention, final asset state and evidence reference. Training covers routine release, airspace/site approvals, cabinet exchange, robot route supervision, wireless charging, emergency stops, battery quarantine, offline behavior and fault ownership.

Training role	Required practical topics
Operator	Status interpretation, task release, normal return, alarm acknowledgement and handover
Flight-responsible person	Aircraft preflight, route approval, failsafe and alternate recovery
Supervisor	Exception approval, incident review and return-to-service decision
Service technician	Isolation, retained loads, charge stop, interlocks, robot stability and affected-function checks
Administrator	Roles, logs, data export, retention and configuration control

F7. Terminology

Event ID. Common reference linking observations, air and ground tasks, approvals, alarms, work orders and outcome.

Task ID / request ID. Identifier of a specific task or command request; a route revision receives its own version.

Requested / accepted / confirmed. Command submitted / device accepted / independent feedback established the physical result.

Eligible aircraft battery. Matched module whose identity, charge, health, temperature and electrical/mechanical conditions permit selection.

Receiving bay. Empty cabinet bay reserved for the returning aircraft's used battery module.

Aircraft-ready handover. Hangar ground handling completed; separate aircraft checks and flight release still apply.

Predicted landing SOC. Current battery percentage less the estimated remaining-route and approach energy, expressed as a percentage of full-charge usable battery energy. The contingency margin and landing reserve floor are checked separately.

SOC / SOH. Battery state of charge / state of health; SOH changes the usable-energy estimate.

Robot docked / charging. Parking and alignment confirmed / actual power transfer confirmed after BMS permission.

Controlled abort. State-specific stop recording the last confirmed physical position and retained load.

Stale data. Device observation older than its configured freshness limit; last-known data stays labeled.

Model confidence. Score from a named model version for one observation; it is not a verified incident probability.

Verified event. Finding supported by an independent view, operator review or field report with source and time retained.

Return-to-service. Named person records the repair, affected-function check and permission to dispatch again.

Local trust domain. Customer-controlled site environment holding continuous raw video unless export policy permits selected media.

Exclusion zone. Area reserved around aircraft launch/recovery, moving hangar parts or robot movement and charging.