

The Southeast Asia duty spec

A robot that passes its factory test in Shenzhen or Boston meets a different world at a Singapore hawker centre or a Jakarta mall. This is the duty specification we hold every robot to before we put it to work, with the number behind each line and where the number comes from.

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Most robot datasheets quote an operating range of 0 to 40 °C at 20 to 80% relative humidity, non-condensing. Southeast Asia sits in the top corner of that envelope every afternoon, and "condensing" is the daily case for any robot that rolls from an air-conditioned lobby into a loading bay. The five cities we work in share one climate, one voltage, two plug families, five languages and a building stock that was designed around wheelchairs, trolleys and cleaners' carts. None of that is in a datasheet. This sheet puts it in one place.

We wrote it for three readers. A robot maker who wants to sell here and would rather learn the environment from a document than from a warranty claim. A buyer who needs a checklist to hand to a vendor. And ourselves, because every line below is a test we run before a robot goes on a site under our name.

HOW TO READ THE SHEET

Section 09 is the requirements sheet itself: 24 numbered lines, each with a requirement, the number behind it and the test we use. Sections 01 to 08 are the evidence. Numbers carry a mark: ● **VERIFIED** when read on a regulator, standards body or met service page, ● **REPORTED** when they come from press or a vendor, ● **ESTIMATE** when we computed or inferred them.

01 The climate envelope

All five cities are within 14 degrees of the equator. The daily pattern is the same from Singapore to Bangkok: a warm night near 25 °C, an afternoon near 32 to 34 °C, humidity that rarely drops below 60% and sits above 85% from midnight to dawn, and a thunderstorm on roughly one afternoon in two during the wet months. The variation between cities is smaller than the variation between a lobby and a car park in any one of them.

CITY	MEAN DAILY MAX	MEAN DAILY MIN	MEAN HUMIDITY	RAIN A YEAR	RAIN DAYS	RECORD HIGH	BASIS
Singapore	30.5 to 32.4 °C	24.3 to 25.7 °C	82%	2,113 mm	171	37.0 °C	MSS normals ⁸ ● VERIFIED
Kuala Lumpur	32.9 °C	24.4 °C	81%	2,847 mm	167	38.5 °C	WMO normals ¹³ ● REPORTED
Jakarta	32.5 °C	about 24.8 °C	81%	1,933 mm	118	37.9 °C	WMO normals ¹⁴ ● REPORTED
Ho Chi Minh City	33.0 °C	24.9 °C	78%	1,970 mm	121	40.0 °C	QCVN 02:2009 ¹⁵ ● REPORTED
Bangkok	33.7 °C	25.4 °C	73%	1,702 mm	105	41.0 °C	WMO normals ¹⁶ ● REPORTED

Singapore's figures are the Changi climate station's 1991 to 2020 normals; its pre-dawn humidity averages 93 to 97%, and the record was set at Tengah in 1983 and tied at Ang Mo Kio on 13 May 2023. Kuala Lumpur, Jakarta and Bangkok are WMO 1991 to 2020 normals as reproduced in reference tables, and Ho Chi Minh City comes from the Vietnamese building code QCVN 02:2009.⁸ Bangkok's hottest day in a typical year reaches 38.4 °C, and its record was set on 7 May 2023.¹⁶ Singapore's highest measured heat stress, a wet-bulb globe temperature of 35.0 °C, came on 31 October 2025 at Sentosa, in a year with 29 high heat stress days.¹⁰ ● VERIFIED

Two numbers matter more than the averages. The first is the record maximum, because the robot's electronics and battery meet it on a loading dock, under a skylight or in a parked van. The second is the night-time humidity, because a robot that charges overnight in an unconditioned store room spends eight hours at 90% humidity and then warms up at dawn.

Haze

Every few years, forest fires in Sumatra and Kalimantan put smoke over Singapore, Kuala Lumpur and Jakarta for weeks. The worst episode pushed Singapore's 24-hour Pollutant Standards Index to 322 on 25 September 2015, in a season with ten unhealthy episodes, the longest lasting 164 hours,¹¹ and haze was back at unhealthy levels across the island on 15 September 2026.¹² ● VERIFIED for 2015, ● REPORTED for 2026. Fine particles clog filters, coat lidar windows and cameras, and settle on fans. A

robot specified for clean indoor air meets, for those weeks, air that would be rejected at the factory gate.

02 Condensation, the daily failure nobody tests

Interiors in the region are cooled to 22 to 24 °C. Outside, a typical afternoon is 32 °C at 80% humidity, and the dew point of that air is about 28 °C ● **ESTIMATE**. A robot that has sat in the lobby for an hour has a skin temperature of about 23 °C. When it crosses the threshold, every surface it owns is 5 °C below the dew point of the air around it, and water forms on it at once: on the camera windows, inside the lidar hood, on the circuit boards behind every vent, and on the connector pins. The water dries off in about twenty minutes. The residue, salts and dust carried in the film, stays and corrodes.

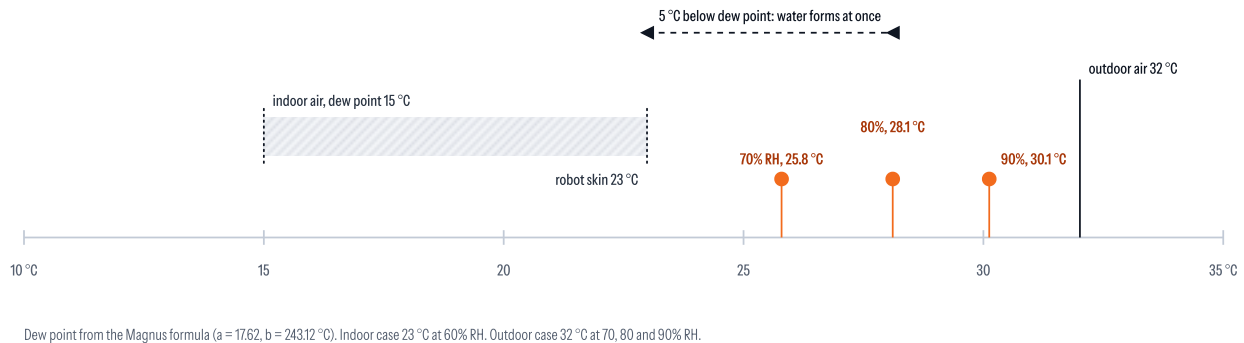


FIG 1 A robot cooled to 23 °C indoors crosses into 32 °C outdoor air whose dew point is 26 to 30 °C. Every surface on it is below the dew point, so condensation is certain, with no rain and no splash.

● **ESTIMATE**

The standards have a word for this air. At 32 °C and 85% humidity it holds 28.6 g of water per cubic metre, above the 25 g ceiling of class 3K3 in IEC 60721-3-3, the weather-protected class most indoor electronics are specified to. ¹⁸ ● **ESTIMATE** against a ● **REPORTED** class limit.

The relevant test exists. IEC 60068-2-30 is a damp heat cyclic test that holds the equipment at 25 °C, raises it to 40 or 55 °C at 95% humidity over 12 hours and brings it back down, repeated, with condensation on the sample as a stated feature of the test ● **VERIFIED**. ¹ Few service robot datasheets mention it. We ask for it, and if the maker has no report we run two cycles ourselves before a robot is accepted.

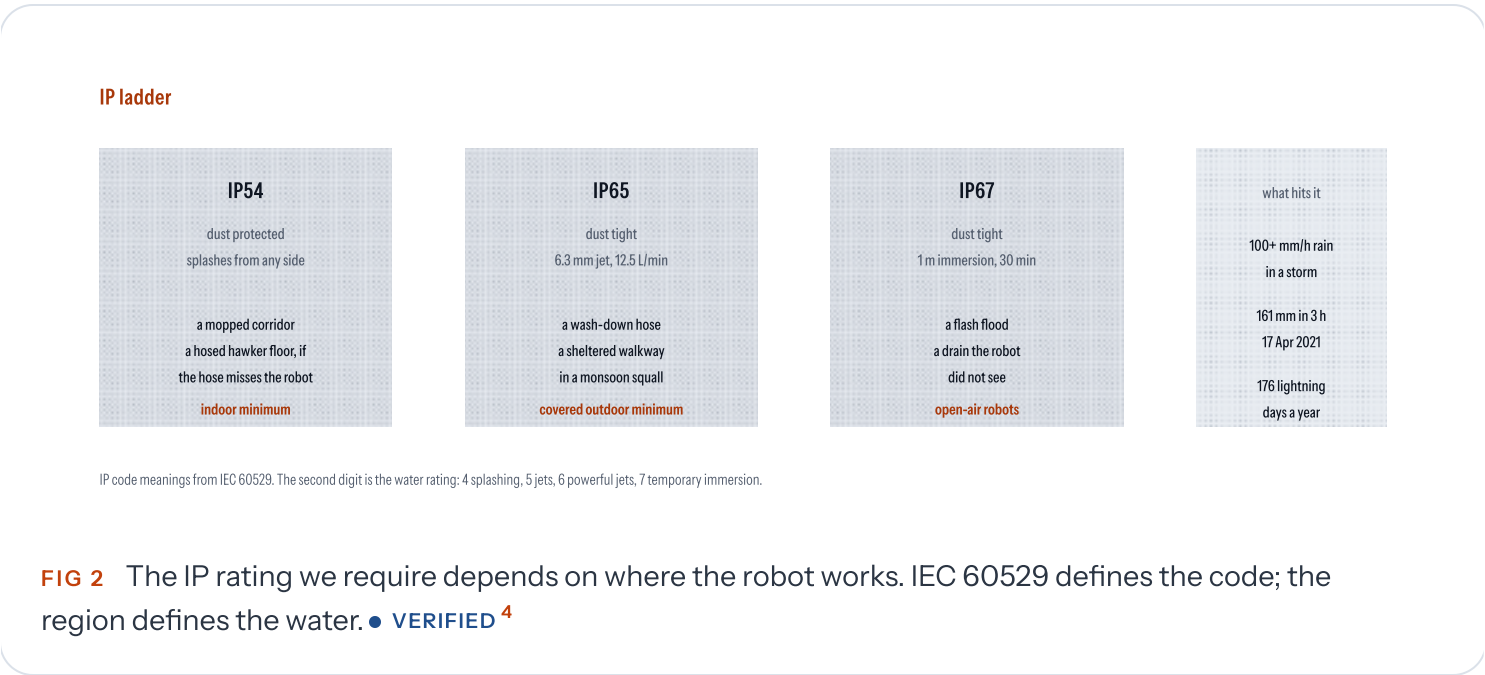
The design answers are known from outdoor telecoms and marine electronics: conformal coating on every board, sealed and gold-plated connectors, breathable membrane vents so the enclosure

breathes without letting liquid in, heated or hydrophobic camera and lidar windows, and a boot routine that waits for the optics to clear before the robot trusts them.

03 Rain, wash-downs and wet floors

Singapore has about 176 lightning days a year, among the highest counts in the world • **VERIFIED**.² The storms that bring the lightning bring rain at rates above 100 mm an hour. Changi's records are 147 mm in 60 minutes and 96 mm in 30 minutes, both on 2 November 1995,⁹ • **VERIFIED** western Singapore took 161.4 mm in three hours on 17 April 2021,³ and Kuala Lumpur's city centre gauge recorded over 114 mm in an hour on 15 October 2024.¹⁷ • **REPORTED** An outdoor delivery robot caught by one of these storms is not in drizzle. It is under a water load that a garden hose cannot reproduce.

Indoors is wetter than makers expect. Hawker centres and wet markets are hosed down daily. Mall atriums have planters that are watered at night. Hospital corridors are mopped on a schedule. Floors are polished homogeneous tile, which is near frictionless when wet, and drains have gratings with slots wide enough to trap a small castor.



What the market ships, from the makers' own manuals. Pudu's CC1 cleaning robot is IPX4, rated 1 to 40 °C at up to 85% humidity, and cleared for a 20 mm obstacle and a 35 mm gap.¹⁹ Its BellaBot Pro delivery robot is IP20, indoor only, with the instruction "do not use the robot in a humid environment".²⁰ Gausium's Phantas is IPX3, rated to 45 °C but only to 75% humidity, and its manual says not to use it outdoors on rainy days; the Scrubber 50 carries the same 75% ceiling.^{21 22} Avidbots' Neo 2 and Unitree's Go2 stop at 35 °C,^{23 24} and Unitree publishes no ingress rating for the Go2 or the G1, whose manuals say they are not waterproof.²⁵ Boston Dynamics' Spot, the outdoor reference, is

IP54 and rated to 55 °C.²⁶ Set those against the climate table: Singapore's monthly mean humidity never drops below 80%, and Bangkok passes 35 °C on an ordinary hot day. Most of these machines are specified for an air-conditioned floor, and that is where they should stay until the maker's test report says otherwise. ● VERIFIED, G1 ● REPORTED

04 Heat inside the robot

The battery is the part that ages fastest in the tropics. Sitting hot is the mechanism, more than cycling. Sandia's accelerated life tests put the activation energy of capacity fade at about 50 to 55 kJ/mol,²⁷ which works out to a pack at 35 °C ageing roughly twice as fast as one at 25 °C, and one at 45 °C roughly four times as fast. ● ESTIMATE Battery University's widely cited storage table says the same in plainer numbers: a full lithium-ion pack keeps about 80% of its capacity after a year at 25 °C and about 65% at 40 °C.²⁸ ● REPORTED A pack that keeps 80% of its capacity for four years in a 25 °C warehouse reaches the same point in about two in a 35 °C store room, ● ESTIMATE and the robot that charges in that store room at night loses capacity faster still, because charging hot is the worst case for lithium cells. Unitree's G1 refuses to charge above a battery temperature of 50 °C.²⁵

Compute throttles. The embedded computers in service robots are specified to 40 or 50 °C ambient at the heatsink, and they reach that inside a sealed enclosure in a 33 °C room with the fans fighting dust filters. When they throttle, perception frame rates drop and the robot slows or stops with no fault code, which reads to the site as "the robot is lazy in the afternoon". We log board temperature with every fault for this reason.

Charging has rules. Singapore's Fire Code treats stored lithium energy above 20 kWh as an energy storage system, with fire-rated compartments, denser sprinklers and ventilation, and a cap of 600 kWh per compartment,²⁹ ● REPORTED and the Ministry of Home Affairs confirmed in January 2026 that workplaces storing and charging larger quantities of lithium batteries fall under those provisions.³⁰ ● VERIFIED A fleet of 47 humanoid packs at 421 Wh each crosses the 20 kWh line, ● ESTIMATE and whether a robot charging bay counts as an energy storage system is not settled in anything we have read. The practical requirement is a charger that stays under 45 °C at the cell during a full charge in a 35 °C room, and a dock in a ventilated space, not a cleaner's cupboard.

05 Power and the grid

All five countries run 220 to 240 V at 50 Hz, which is the easy part. The plugs differ: Singapore and Malaysia use the British Type G, Indonesia the European C and F, Vietnam A, C and F, and Thailand C, F and its own Type O.³¹ ● REPORTED, because the IEC's own plug reference refused our reads.⁵ A dock shipped with the wrong lead is a week lost, so we specify an IEC C14 inlet on every dock and carry the leads.

COUNTRY	MAINS	PLUGS	OUTAGE MINUTES PER CUSTOMER, 2024	SOURCE FOR THE OUTAGE FIGURE
Singapore	230 V, 50 Hz	G	0.26, with 0.006 interruptions	Energy Market Authority sustainability report ³² ● REPORTED
Malaysia	230 V, 50 Hz	G	47.9	TNB annual report, Peninsular distribution ³³ ● REPORTED
Indonesia	230 V, 50 Hz	C, F	320, with 3.2 interruptions	PLN, via ANTARA ³⁴ ● REPORTED
Vietnam	220 V, 50 Hz	A, C, F	about 231 nationally	EVN year-end review ³⁵ ● REPORTED
Thailand	220 V, 50 Hz	C, F, O	15.1 in Bangkok, with 0.51 interruptions	Metropolitan Electricity Authority ³⁶ ● REPORTED

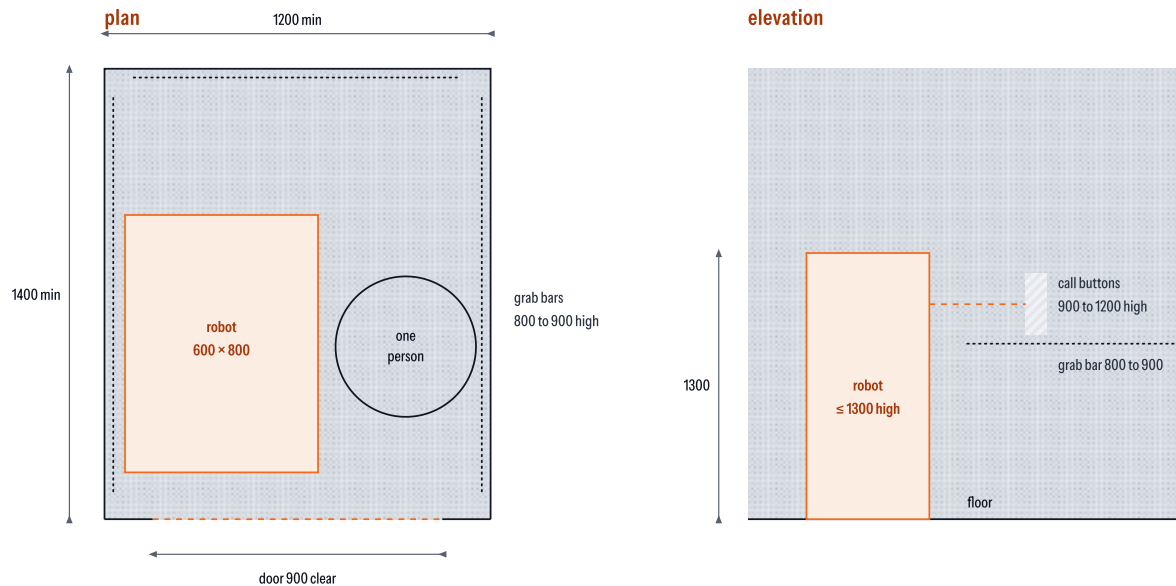
Grid quality is the real difference between the cities. A dock in Jakarta sees roughly twenty times the outage minutes of one in Bangkok and over a thousand times Singapore's. ● ESTIMATE The outages that matter are the big ones. Northern Vietnam's rolling cuts in May and June 2023 cost about US\$1.4 billion by the World Bank's early estimate,³⁷ Bali went dark island-wide on 2 May 2025,³⁸ and a Sumatra blackout from 22 to 26 May 2026 took out eight provinces, with Medan off for about 19 hours.³⁹ ● REPORTED A robot that loses its dock in a brownout must restart its charge without a human, and a fleet that loses the building's Wi-Fi for twenty minutes must keep working from what it has cached.

Lightning is a power problem too. With 176 lightning days a year in Singapore and similar counts up the peninsula, surges on the mains and on long Ethernet runs are routine. We require surge protection on the dock's mains input and on any wired network port, and we have replaced enough dead chargers to know why.

06 The building: lifts, doors, ramps and floors

Singapore's Code on Accessibility in the Built Environment 2019 sets the dimensions a robot inherits, because buildings are built to it and a robot that fits a wheelchair's space fits the building. The lift designated for wheelchair users must have an internal car of at least 1200 mm wide by 1400 mm deep, a clear door opening of at least 900 mm, grab bars on three sides at 800 to 900 mm, and call buttons mounted 900 to 1200 mm above the floor and at least 350 mm from any wall ● VERIFIED .⁶ The lobby in front of it must have a clear space of 1200 by 1500 mm.⁶ For building plans submitted from 1 November 2025 the 2025 edition deepens the car to 1500 mm, widens accessible

gates to 900 mm and makes shelter over accessible routes mandatory where sheltered walkways exist.⁴¹ ● VERIFIED



Code on Accessibility 2019, clauses 4.9.2.1, 4.9.3.1, 4.8.3.1 and 4.9.4.1. Robot envelope is ours, drawn to scale.

FIG 3 A robot with a 600 by 800 mm footprint and a height under 1300 mm fits the minimum accessible lift car of the 2019 code with one person beside it, clears the 900 mm door, and reaches the buttons without an arm by talking to the lift instead. Cars in buildings planned from November 2025 are 100 mm deeper. ● VERIFIED dimensions, ● ESTIMATE envelope

Three consequences follow. A robot that must ride lifts needs a footprint near 600 by 800 mm and a height under 1300 mm so that one person can still share the car. It should never share a car with a wheelchair user, because the 1200 by 1400 minimum leaves no room; the robot waits. And it should not press buttons at all. Singapore's standard SS 713:2025 defines how a robot talks to a lift or a door over a network, promoted from the earlier Technical Reference TR 93 ● VERIFIED,⁷ and a growing share of new buildings in the region install lifts that support it. We specify SS 713 support as a requirement for any robot that works across floors.

Ramps in the code run at 1:12 for at most 6 m between landings, gentler for longer runs, with 1,200 mm minimum width and a cross fall no steeper than 1:40; kerb ramps may be 1:10; a level change of up to 15 mm may be a 1:2 lip, and gratings on accessible routes must be flush with gaps of 12 mm or less.⁴⁰ Doorway clear openings are 850 mm, lift doors 900 mm, and accessible routes 1,200 mm wide in most buildings and 1,800 mm in malls, MRT stations, hawker centres and hospitals, with an 1,800 by 1,800 mm passing space where narrower.⁴⁰ ● VERIFIED Singapore has also built 186 km of covered walkways since 2013, with 50 km more planned around MRT stations,⁴² which is the covered outdoor duty in the sheet. Floors are the problem that no code solves: homogeneous tile

with a thin film of water has a low enough friction that a robot braking at 1 m/s slides, so we require a wet-tile braking test on every drive wheel compound.

07 Networks

Every robot we deploy has a cellular modem, because site Wi-Fi is the most common single point of failure in a fleet and the least likely to be fixed by the site. The bands differ by country and operator, and a modem bought for China or Europe may not cover them.

COUNTRY	5G BANDS IN USE	WHO RUNS THEM	MEDIAN MOBILE SPEED, AUG 2026
Singapore	n78 (3.5 GHz) with 100 MHz each to two networks, n1 (2.1 GHz) for standalone 5G, 26 and 28 GHz assigned ⁴³ ● REPORTED	Singtel; the M1 and StarHub consortium	164 down, 22 up ⁵¹
Malaysia	n78 at 3.3 to 3.5 GHz, 200 MHz on the national wholesale network since U Mobile left it on 30 June 2026 ⁴⁴ ● VERIFIED	CelcomDigi, Maxis and YTL on DNB; U Mobile on its own standalone network since August 2025 ⁴⁵	165 down, 24 up
Indonesia	n28 (700 MHz) and n41 (2.6 GHz), auctioned July 2026 with 51% population coverage due by 2029; earlier 5G on 2.1 and 2.3 GHz ⁴⁶ ● REPORTED	Telkomsel, Indosat, XLSmart	66 down, 20 up
Vietnam	n41 (2.5 to 2.6 GHz) nationwide since October 2024; 3.7 to 3.8 GHz; and 3.8 to 3.9 GHz, which sits outside n78 so the modem needs n77 ^{47 48} ● REPORTED	Viettel; VNPT; MobiFone	220 down, 40 up
Thailand	n28 (700 MHz), n41 (2.6 GHz) and n258 (26 GHz) from the 2020 auction; 850, 1500, 2100 and 2300 MHz added in 2025 ⁴⁹ ● REPORTED	AIS; True	134 down, 25 up
All five	Wi-Fi in the 6 GHz band is allowed in the lower 500 MHz, 5,925 to 6,425 MHz, in every country on the Wi-Fi Alliance's list, with one conflicting 2024 note on Vietnam. ⁵⁰ ● VERIFIED A regional robot modem's LTE list looks like the BellaBot Pro's: FDD bands 1, 3, 7, 8, 20 and 28 and TDD bands 34, 38 and 40. ²⁰		Mbps, Ookla medians

Ookla medians come from user-run tests and sit several times above passive averages, which put Thailand's and Indonesia's operators near 30 to 40 Mbps down. Upload is the binding number for any robot that streams video to a remote operator, and it is 20 to 40 Mbps at the median everywhere.

Three registration rules bite a fleet. Thailand caps SIMs at five per individual and makes holders of more re-verify or lose service, so fleet SIMs go on a company account.⁵² ● **REPORTED** Vietnam, from 15 April 2026, suspends a SIM's outbound service within two hours of it appearing in a different device until the holder passes facial biometric verification, with no machine-to-machine exemption we could find,⁵³ ● **VERIFIED** so moving a SIM between robots is a support ticket. Indonesia blocks cellular handsets whose IMEI is not registered; whether an embedded robot modem is covered is not stated in what we read.⁵⁴ ● **REPORTED** The design requirement is a modem that covers the LTE and 5G bands of at least two operators in each country, a SIM that can be swapped without opening the chassis, and firmware that keeps the robot working from a local map and a local task queue for at least 30 minutes with no network at all.

08 People, languages and wages

The five countries have five national languages: English, Malay, Chinese and Tamil in Singapore; Malay in Malaysia; Indonesian; Vietnamese; Thai. English carries business in Singapore and Malaysia and is a second language elsewhere. A robot that greets, warns and asks for help must do so in the language of the cleaner on the night shift, who is the person who will rescue it. On the EF English Proficiency Index 2025, Malaysia ranks 24th of 123 countries, Vietnam 64th, Indonesia 80th and Thailand 116th; Singapore is treated as native English and is no longer ranked.⁵⁵ ● **REPORTED** Even in Singapore, English became the most common language at home only at the 2020 census, at 48%.⁵⁶ Google and Microsoft cover Malay, Indonesian, Thai and Vietnamese in both speech synthesis and recognition, Amazon transcribes all four but speaks none of them, and ElevenLabs lacks Thai in its main models.^{57 58 59 60} ● **VERIFIED** We require the robot's spoken and on-screen phrases to be editable by us, in each language, without a firmware release.

Wages set the price a robot has to beat. Singapore's cleaning wage floor from 1 July 2026 is S\$2,080 a month for a general cleaner and S\$2,700 for a machine operator.⁶¹ ● **VERIFIED** Malaysia's minimum wage is RM1,700 a month, about S\$520.⁶² Jakarta's 2026 provincial minimum is Rp5,729,876, about S\$450;⁶³ Vietnam's region I minimum, which covers Ho Chi Minh City and Hanoi, is VND 5,310,000, about S\$270;⁶⁴ and Bangkok's daily minimum is THB 400, about S\$420 a month at 26 days.⁶⁵ ● **REPORTED**, conversions ● **ESTIMATE** at rough October 2026 rates. A cleaning robot that needs a half-hour of human attention a day has consumed a fifth of the saving it was bought for in Singapore, and all of it in Jakarta. That is why the service lines in the sheet below carry as much weight as the environmental ones.

09 The requirements sheet

Each line is a requirement a robot must meet, the number behind it, and the test we run or the document we ask for. "Covered outdoor" means sheltered walkways, car parks and loading bays. "Open air" means footpaths and parks.

Environment

DS-01 HEAT

Operate continuously at 38 °C ambient and survive 50 °C storage.

Bangkok's hottest day in a typical year is 38.4 °C, the five records run from 37.0 to 41.0 °C, and surfaces in sun run hotter. Test: 8 hours at 38 °C in a chamber, full duty cycle, no throttling below 80% speed.

DS-02 HUMIDITY

Operate at 95% relative humidity, condensing. Night humidity above 85% across the region. Test: IEC 60068-2-30, two cycles of 25 to 40 °C at 95% RH; robot boots and localises within 5 minutes after each cycle.

DS-03 TRANSITIONS

Cross from a 22 °C interior to 32 °C and 85% RH outdoor air ten times a day without a fault. Dew point of the outdoor air is 28 °C. Test: ten cold-to-warm transitions in one day; cameras and lidar must report clear within 3 minutes of each.

DS-04 WATER, INDOOR

IP54 minimum for any robot that works on floors that are mopped or hosed. Hawker centres, wet markets and hospital corridors are washed daily. Test: IEC 60529 second digit 4, plus a drive through a 5 mm film of water for 10 minutes.

DS-05 WATER, COVERED OUTDOOR

IP65 minimum on sheltered walkways, loading bays and car parks.

Wind-driven rain at over 100 mm/h. Test: IEC 60529 second digit 5 on the assembled robot, not on the enclosure alone.

DS-06 WATER, OPEN AIR

IP67 on the drive, battery and compute modules for footpath and

park robots. Flash floods and unseen drains. Test: IEC 60529 second digit 7 on the sealed modules, documented by the maker.

DS-07 DUST AND HAZE **Dust-protected enclosures with filters that can be changed on site in under 5 minutes.** Haze episodes push fine particles to hazardous levels for weeks. Test: filter access with no tools; optics have a wipe routine or a hydrophobic coating.

DS-08 CORROSION **Conformal coating on all boards; stainless or coated fasteners; no bare aluminium contact pairs.** Salt air within 2 km of the coast covers most of Singapore and all of the Jakarta and Ho Chi Minh City waterfronts. Test: board inspection and a 48 hour salt-fog exposure on a sample chassis.

DS-09 LIGHTNING **Surge protection on the dock mains input and on every wired network port.** 176 lightning days a year in Singapore. Test: surge arrestor part numbers in the dock's bill of materials.

Power

DS-10 MAINS **Dock accepts 180 to 264 V at 50 Hz through an IEC C14 inlet.** 220 to 240 V nominal across all five countries, with sags in Indonesia and Vietnam. Test: charge at 190 V and at 250 V; no fault, no derating beyond 10%.

DS-11 OUTAGES **Resume charging without human action after a power cut of any length; keep the robot's task queue through a cut.** Grid interruptions are a monthly event outside Singapore. Test: pull the dock's plug mid-charge for 10 minutes, then restore.

DS-12 BATTERY HEAT **Cell temperature stays below 45 °C through a full charge in a 35 °C room; charging pauses above that.** Ageing roughly doubles for every 10 °C, and a pack at 45 °C ages about four times as fast as one at 25 °C. Test: thermocouple on the pack during a charge in a 35 °C chamber.

DS-13 BATTERY LIFE **80% of rated capacity after 1,000 cycles at 35 °C, with the test report.** Tropical ageing runs ahead of datasheet life. Test: the maker's cycle data at 35 °C or above, or a 90 day fleet capacity log.

Building

DS-14 LIFT ENVELOPE

Footprint within 600 by 800 mm and height within 1300 mm for any robot that rides lifts. Minimum accessible lift car is 1200 by 1400 mm with grab bars on three sides. Test: tape measure; the robot and one adult share the minimum car.

DS-15 LIFT AND DOOR INTEGRATION

SS 713:2025 robot-to-infrastructure communications for any robot that works across floors. Robots do not press buttons. Test: the maker names the lift and door controllers it has integrated with, and the robot rides a lift unassisted on site.

DS-16 GRADIENT

Climb and brake on a 1:12 ramp for 6 m at full payload, take a 1:10 kerb ramp, and cross a 15 mm lip. The accessibility code's ramp, kerb ramp and level-change limits. Test: ramp, kerb and threshold on the site walk.

DS-17 WET FLOOR

Stop within 1.5 m from 1 m/s on wet homogeneous tile. Polished tile with a water film is the regional floor. Test: braking distance on a wetted tile at the depot.

DS-18 DRAINS AND GAPS

Castors and drive wheels cross a 35 mm grating slot and a 20 mm obstacle without trapping. The code limits gaps on accessible routes to 12 mm, but back-of-house drains and hawker washing bays are wider; Pudu rates its CC1 for a 35 mm gap and a 20 mm obstacle, which is the bar. Test: a grating sample at the depot.

Network and data

DS-19 CELLULAR

Modem covers the LTE and 5G bands of at least two operators in each deployment country; SIM accessible without opening the chassis. Bands differ by country and operator. Test: band list against the table in section 07; a live attach on each operator.

DS-20 OFFLINE

Works from a local map and task queue for 30 minutes with no network; recovers without a reboot. Site Wi-Fi fails more often than the robot. Test: block the robot's traffic for 30 minutes mid-task.

DS-21 DATA RESIDENCY Video and audio stay in the deployment country unless the site agrees in writing; the maker's remote access is logged and can be switched off by the operator. Five data protection laws, all of which treat camera footage as personal data. Test: network capture of a working robot for 24 hours; every destination accounted for.

People and service

DS-22 LANGUAGE Spoken and on-screen phrases editable in English, Malay, Indonesian, Vietnamese, Thai and Chinese without a firmware release. The night-shift cleaner rescues the robot. Test: change a phrase in each language and hear it on the robot.

DS-23 FIELD REPAIR Battery, drive wheel, bumper, castor and the top three failing modules swap on site in under 30 minutes with hand tools; fault codes readable without the maker's cloud. Attention time eats the wage saving. Test: a timed swap of each module by our technician.

DS-24 SPARES Spares for every DS-23 module held in the deployment country, with a 48 hour replacement commitment in writing. Shipping a wheel from Shenzhen takes a week plus customs. Test: the spares list and the stock location on the contract.

WHAT THIS SHEET IS FOR

A maker reading it knows what to build and what to test before the first container ships. A buyer can paste it into a tender. We publish it because the alternative is learning each line from a warranty claim, which is what the region has done so far. If you have a number that corrects one of ours, write to us and we will change it and credit you.

SOURCES

1 [IEC 60068-2-30:2005, Environmental testing, Test Db: Damp heat, cyclic \(12 h + 12 h cycle\)](#) IEC

2 [Weather systems: lightning, Meteorological Service Singapore](#) read 2 Oct 2026

- 3 [Singapore: flash floods after 161.4 mm of rain in western Singapore, 17 April 2021](#) FloodList, citing PUB
- 4 [IEC 60529:1989+AMD1:1999+AMD2:2013, Degrees of protection provided by enclosures \(IP Code\)](#) IEC
- 5 [World plugs, by country](#) IEC
- 6 [Briefing on accessibility requirements for lifts, Code on Accessibility in the Built Environment 2019, clauses 4.8 and 4.9](#) BCA, April 2024
- 7 [Robotics standards in Singapore, including SS 713:2025 robot-to-infrastructure communications](#) National Robotics Programme
- 8 [Climate of Singapore, 1991 to 2020 normals, Meteorological Service Singapore](#) page dated 21 Aug 2024
- 9 [Historical extremes, Meteorological Service Singapore](#) updated 13 Aug 2026
- 10 [Annual Climate Assessment Report 2025, Meteorological Service Singapore](#) Apr 2026
- 11 [Annual Climate Assessment Report 2015, Meteorological Service Singapore](#) Mar 2016
- 12 [Haze: PSI in the unhealthy range across Singapore, CNA](#) 15 Sep 2026
- 13 [Kuala Lumpur, climate table reproducing WMO 1991 to 2020 normals](#) read 2 Oct 2026
- 14 [Jakarta, climate table reproducing 1991 to 2020 normals](#) read 2 Oct 2026
- 15 [Ho Chi Minh City, climate table reproducing QCVN 02:2009](#) read 2 Oct 2026
- 16 [Bangkok, climate table reproducing WMO 1991 to 2020 normals](#) read 2 Oct 2026
- 17 [DBKL: heavy rainfall of 114 mm an hour cause of flash floods across Kuala Lumpur, Malay Mail](#) 15 Oct 2024
- 18 [IEC 60721-3-3:1994, classification of environmental conditions, stationary use at weather-protected locations \(sample\)](#)
- 19 [Pudu CC1 product introduction and specifications, Pudu Academy](#) read 2 Oct 2026
- 20 [BellaBot Pro user guide V1.0, Pudu](#) Jun 2024
- 21 [Phantas user manual V1.1, Gausium](#) 21 Jun 2024
- 22 [Scrubber 50 user manual V4.1, Gausium](#) Mar 2025
- 23 [Neo 2 technical specifications, Avidbots](#)
- 24 [Go2 user manual V1.0, Unitree](#)
- 25 [G1 user manual, Unitree](#) 2025
- 26 [Spot specifications, Boston Dynamics](#) Oct 2020
- 27 [Accelerated life testing of lithium-ion cells, SAND2002-3201J, Sandia National Laboratories](#) 2002
- 28 [BU-808: How to prolong lithium-based batteries, Battery University](#)
- 29 [What fire safety managers need to know about energy storage systems, SCDF seminar](#) 29 Jul 2025
- 30 [Fire safety standards for workplaces that store and charge larger quantities of lithium-ion batteries, Ministry of Home Affairs](#) 13 Jan 2026
- 31 [Mains electricity by country](#) read 2 Oct 2026
- 32 [Annual sustainability report 2024/25, Energy Market Authority](#)
- 33 [Integrated annual report 2024, Tenaga Nasional](#)
- 34 [PLN records a fall in outage duration and frequency in 2024, ANTARA](#) 2025
- 35 [EVN 2024 business and customer service review, Năng lượng Việt Nam](#) 2025
- 36 [Reliability indices, Metropolitan Electricity Authority, Bangkok](#)

- 37** [Power outages cost Vietnam US\\$1.4 billion, World Bank, VnExpress](#) Aug 2023
- 38** [Bali hit by island-wide power outage, CNN](#) 2 May 2025
- 39** [2026 Sumatra blackout](#) read 2 Oct 2026
- 40** [Code on Accessibility in the Built Environment 2019, BCA](#) tables 3, 4, 5 and clauses 3.6.1, 4.1.2.1, 4.4.2.1
- 41** [Circular APPBCA-2025-07, launch of the Code on Accessibility 2025, BCA](#) 7 Apr 2025
- 42** [Written reply on extending covered linkways around MRT stations, Ministry of Transport](#) 8 Apr 2025
- 43** [Singapore operators secure additional spectrum for 5G, RCR Wireless](#) 29 Nov 2021
- 44** [DNB doubles spectrum capacity as U Mobile offboards, Developing Telecoms](#) 2 Jul 2026
- 45** [U Mobile completes transition to its own 5G network, The Star](#) 1 Jul 2026
- 46** [Indonesia 700 MHz and 2.6 GHz spectrum allocation finalised, GMA Labs](#) Jul 2026
- 47** [Vietnam's accelerated 5G rollout, Telecom Review Asia](#) 2025
- 48** [MobiFone wins the auction for 5G spectrum, Viet Nam News](#) Jul 2024
- 49** [Thailand raises more than THB 100 billion in 5G spectrum auction, Telecompaper](#) Feb 2020
- 50** [Countries enabling Wi-Fi in 6 GHz, Wi-Fi Alliance](#) read 2 Oct 2026
- 51** [Speedtest Global Index, Singapore and the other four countries](#) Aug 2026
- 52** [Thailand brings in stronger ID verification measures, Biometric Update](#) Nov 2025
- 53** [Biometric verification required for mobile device changes from April 15, VietnamPlus](#) 10 Apr 2026
- 54** [How to register an IMEI in Indonesia, 2026 update, Noble Asia](#)
- 55** [EF English Proficiency Index 2025](#) Nov 2025
- 56** [Census 2020: more Singaporeans speak English at home, Seasia](#) 23 Feb 2024
- 57** [Supported voices and languages, Google Cloud Text-to-Speech](#) read 2 Oct 2026
- 58** [Language support, Azure Speech](#) read 2 Oct 2026
- 59** [Available voices, Amazon Polly, and supported languages, Amazon Transcribe](#) read 2 Oct 2026
- 60** [Text to speech language support, ElevenLabs](#) read 2 Oct 2026
- 61** [Progressive Wage Model for the cleaning sector, Ministry of Manpower](#) read 2 Oct 2026
- 62** [RM1,700 minimum wage to come into force from August 1, The Star](#) 22 Jul 2025
- 63** [UMP and UMSP DKI Jakarta 2026, Hukumonline](#) 2026
- 64** [Vietnam's new minimum wage from 1 January 2026, Vietnam Briefing](#) Nov 2025
- 65** [Thailand raises the minimum wage for Bangkok from 1 July 2025, BDO](#) Jun 2025

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