

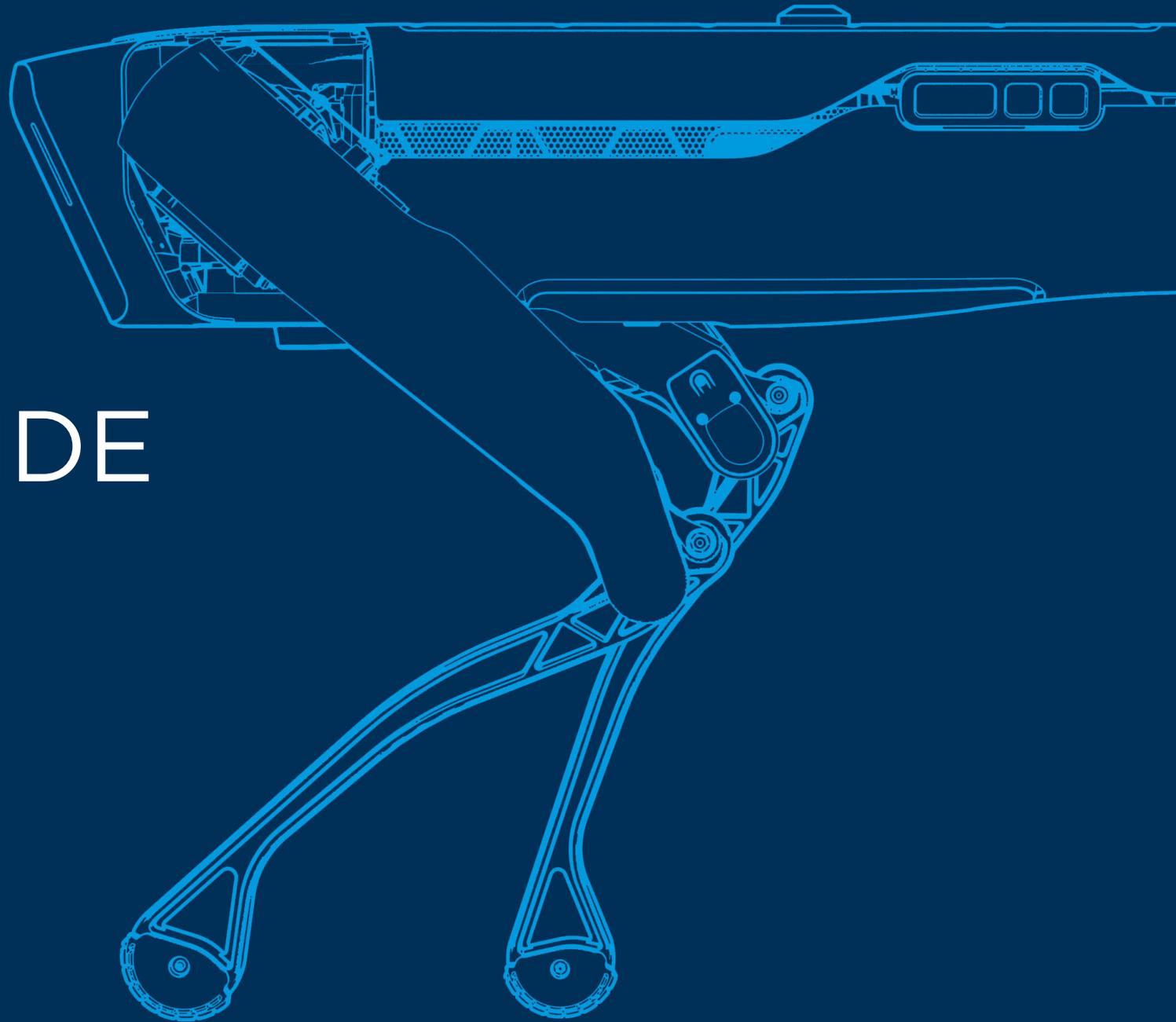
BostonDynamics



SPOT

USER GUIDE

RELEASE 2.0 VERSION A



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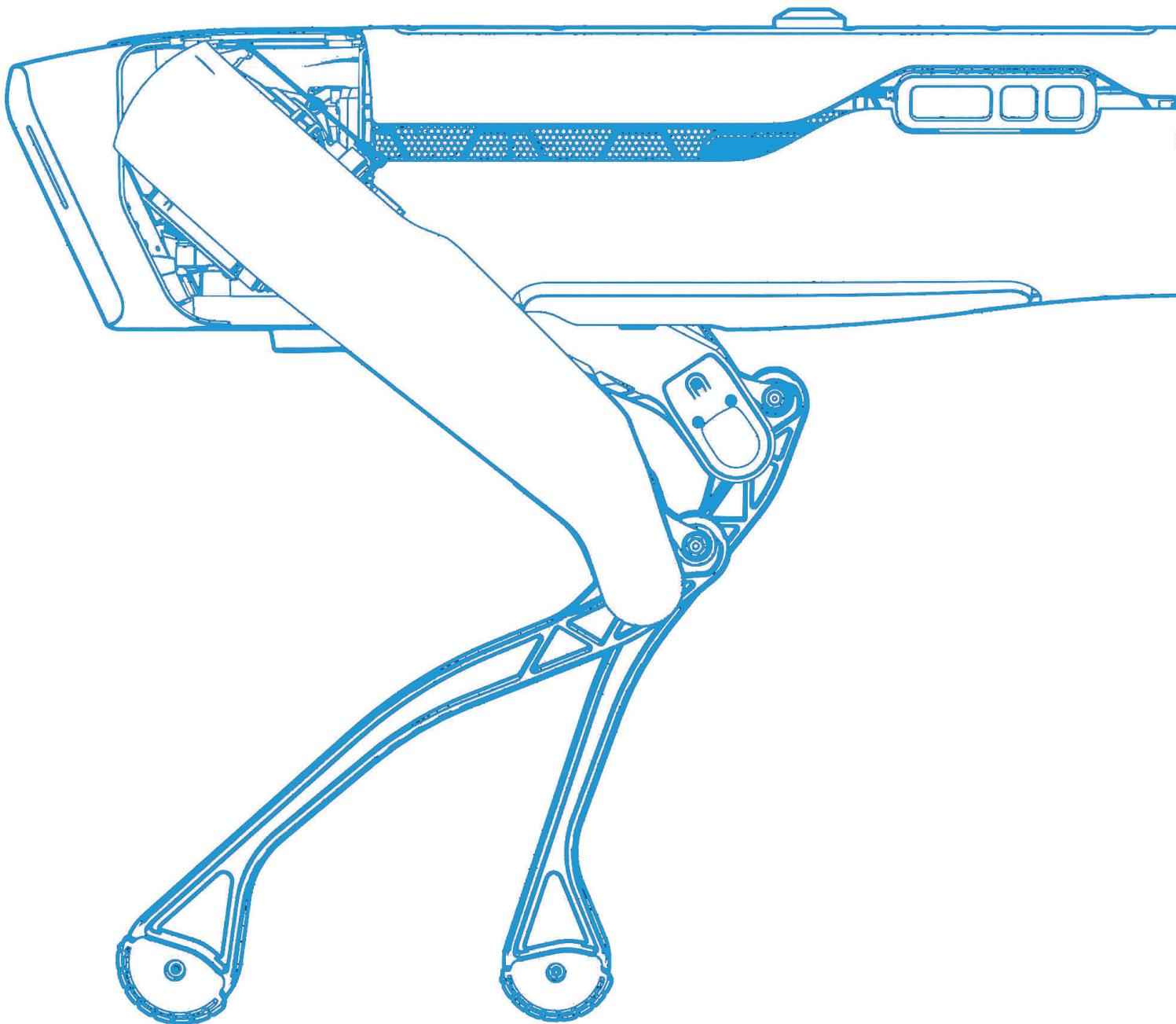
LEGEND



WARNING: Indicates a hazardous situation which, if not avoided, could result in death or serious injury. Such situation could also result in significant damage to the robot or property.



NOTE: Addresses practices not related to safety, including tips to maximize performance and prevent damage to the robot



—
R2.0
VA

INTRODUCING SPOT

HELLO

We've built the world's most advanced four-legged robot. Spot is small enough to navigate human environments, but nimble enough to traverse nearly any terrain. Spot dynamically balances, but is easy to control. As Spot takes its first steps out of the lab, it represents a giant leap toward a future of general-purpose robotics.

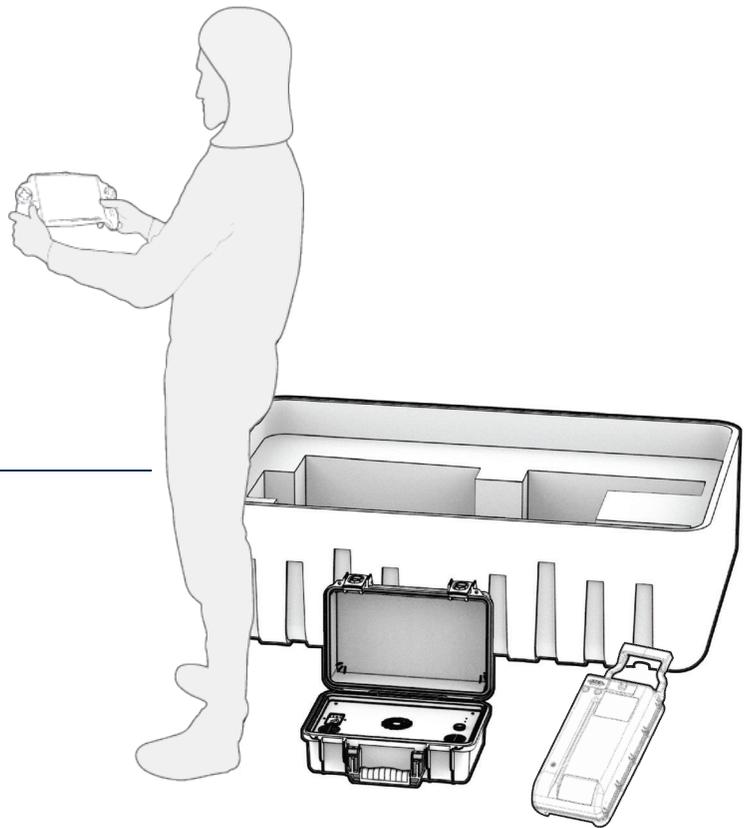
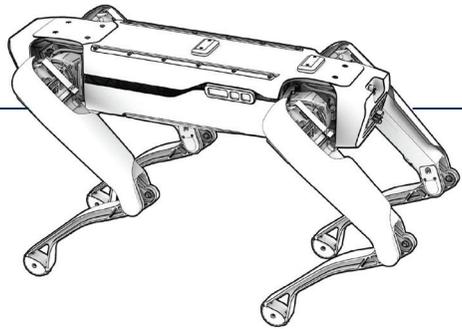
Robotics is a team sport. Boston Dynamics has built the platform - and it's up to you to put it to work. With this user guide, a growing list of payloads, evolving software capabilities, and accessible development kits, you have the tools to leverage this technology to its fullest.

**It's time to change the world's idea of what robots can do.
Let's get started.**

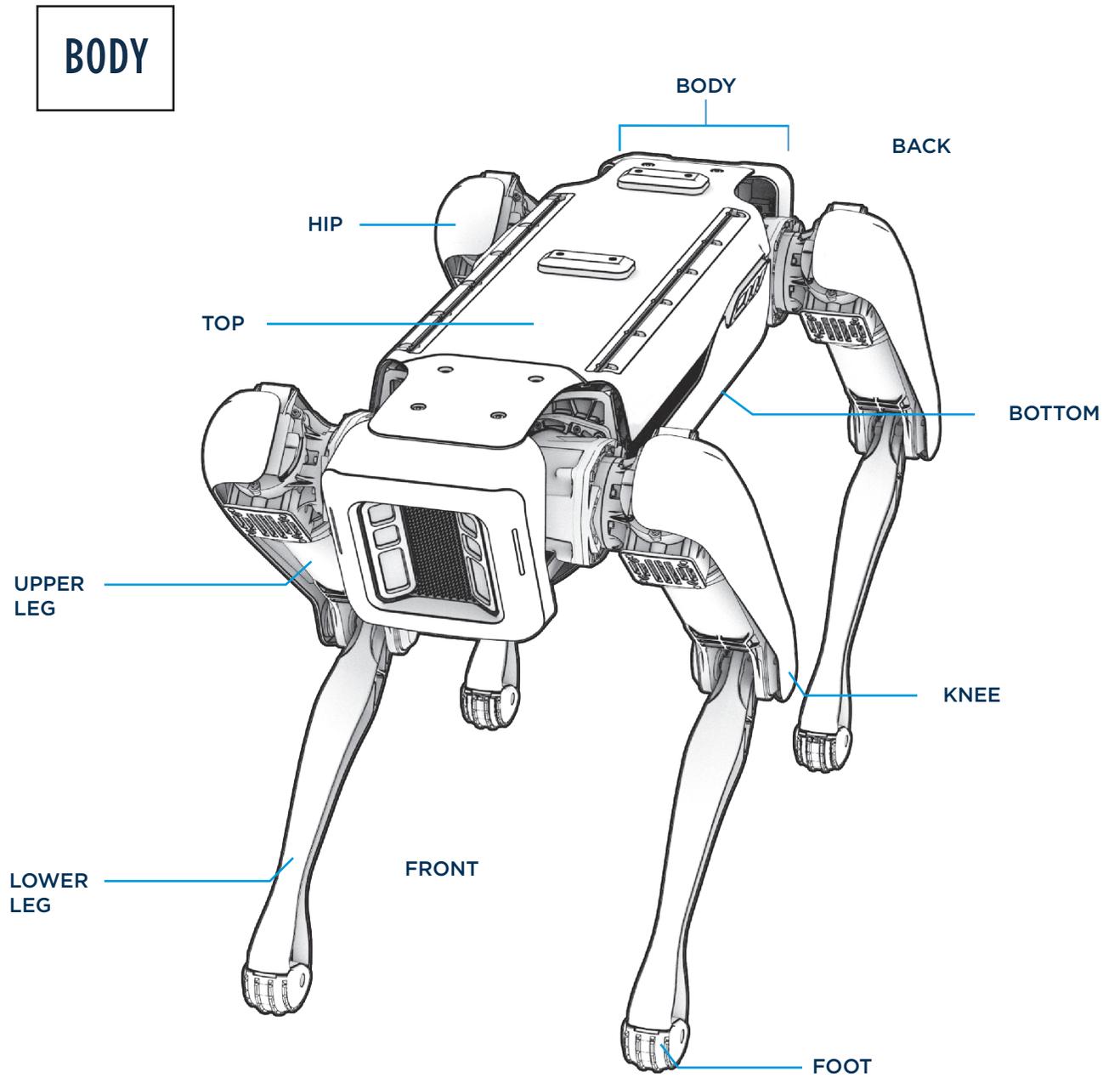
INTRODUCING SPOT

SYSTEM CONTENTS

- Spot Robot
- Battery (x2)
- Charger
- Controller

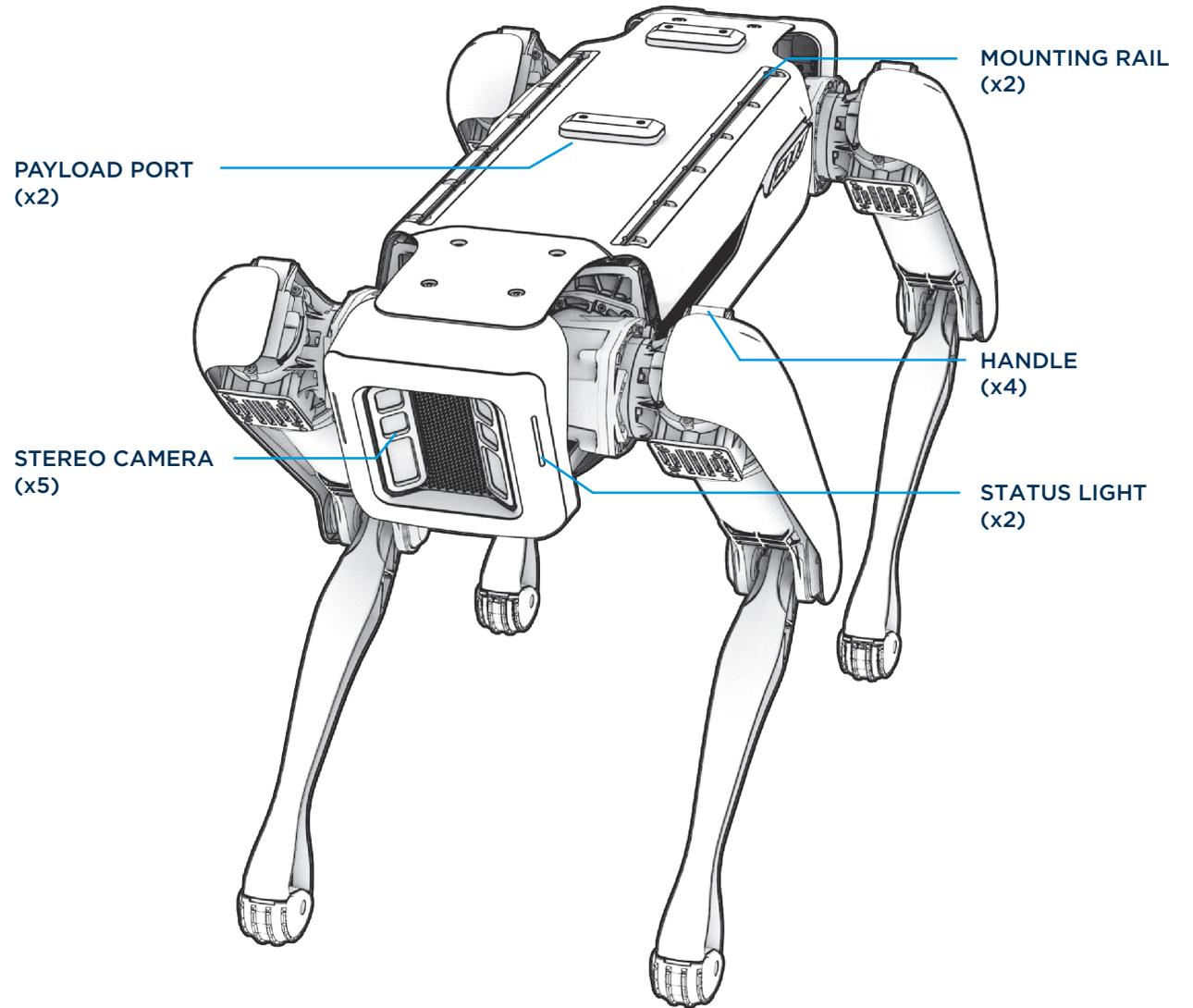


INTRODUCING SPOT



THREE-QUARTER VIEW

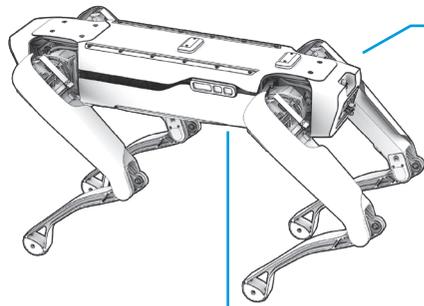
INTRODUCING SPOT



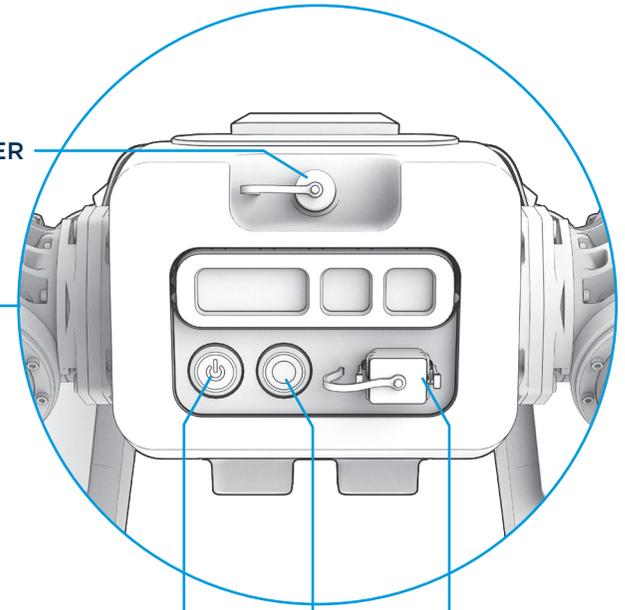
THREE-QUARTER VIEW

INTRODUCING SPOT

BUTTONS & PORTS



BACK VIEW

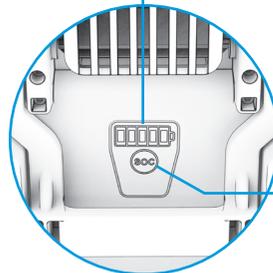


POWER
PORT & COVER

POWER
BUTTON

MOTOR
LOCKOUT
BUTTON

ETHERNET
PORT & CAP



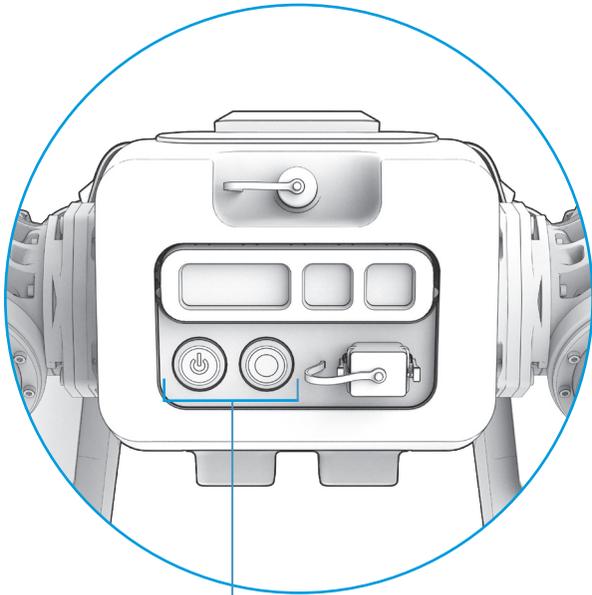
STATE OF CHARGE (SOC) BUTTON
Shows the battery charge level;
located on the battery

BOTTOM VIEW

INTRODUCING SPOT

POWER & MOTOR LIGHTS

BACK VIEW

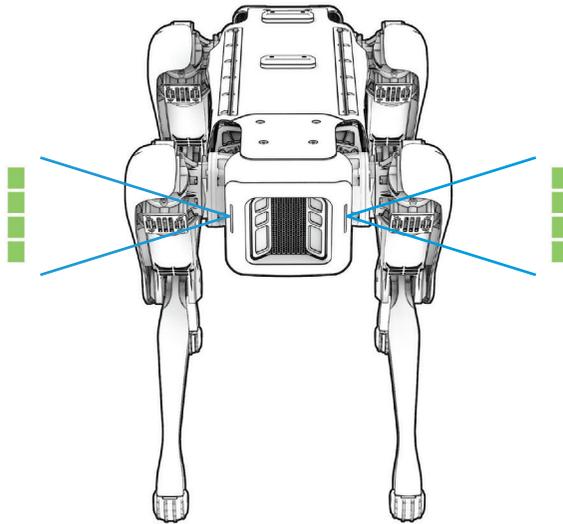


POWER AND MOTOR LIGHTS

POWER BUTTON	LOCKOUT BUTTON	ROBOT STATUS
		NO LIGHTS: Robot and motors off (lockout engaged)
		BLUE LIGHT: Computers on, motors off (lockout engaged)
		SLOWLY FLASHING RED LIGHT: Motors available but not powered
		QUICKLY FLASHING RED LIGHT: Motors turning on
		SOLID RED LIGHT: Motors on - stay at least 2m away

INTRODUCING SPOT

STATUS LIGHTS



POWER



Yellow:
System booting up



Moving rainbow:
Powered on, ready to connect



Solid rainbow:
Plugged in, no battery



Rainbow dots:
Charging, dots show % charge

MOTORS



Solid blue:
Lockout button engaged;
Spot is safe to handle



Slow blink green:
Spot connected; motors may turn on



Fast blink green:
Motors turning on!



Solid green:
Motors on

ERRORS



Blinking orange:
Serious error or perception fault
has occurred; operation degraded

INTRODUCING SPOT

CONTROLLER

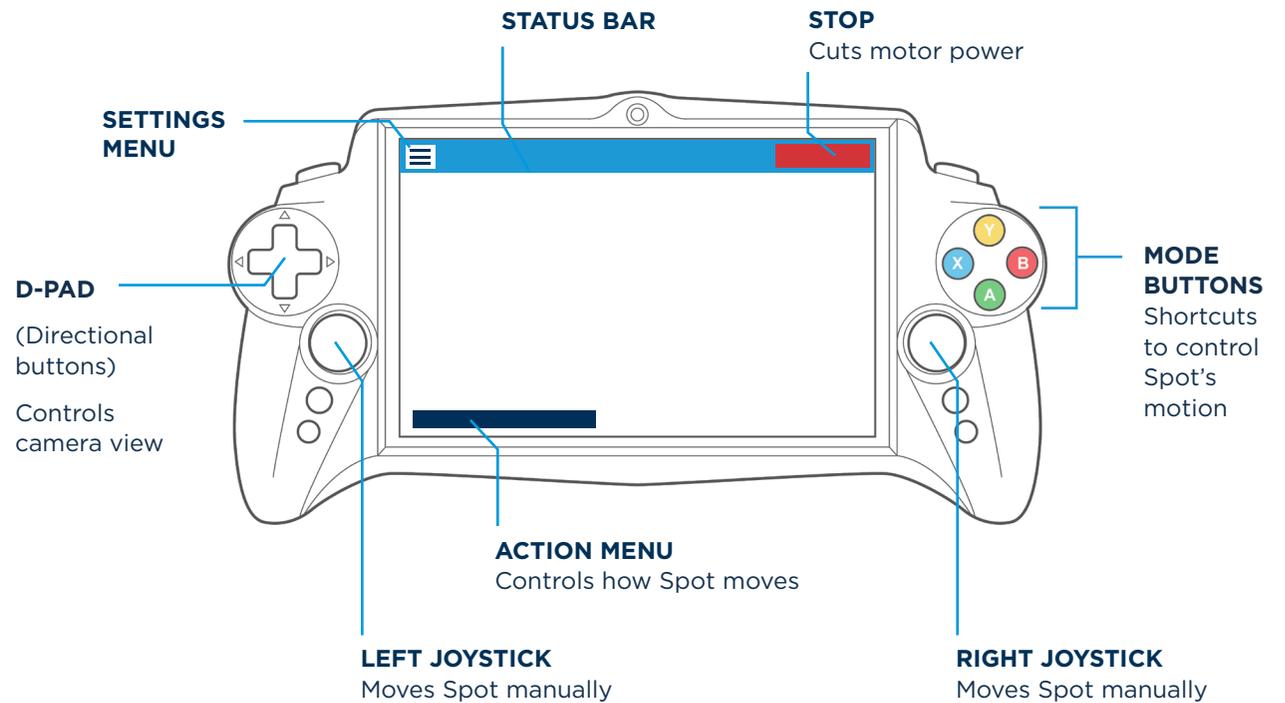
Spot is controlled by an android app running on a tablet. The Spot System includes an Android gaming tablet with physical buttons for easy robot control.

OPERATING MODES

Spot's controller has two operating modes. Change between the modes in the settings menu.

Standard Mode: Provides easy-to-use control for most situations.

Demo Mode: Enables demonstration gaits and adds additional button controls to make it easy to switch modes.



SAFETY

TRAINING

Proper training: Do not use Spot without reading this user guide and understanding safe operation of the robot.

Responsible use of Spot is crucial to prevent dangerous conditions for operators and others nearby. Make sure to read, understand and comply with this user guide to lessen the risk of serious injury, death, or robot and other property damage.

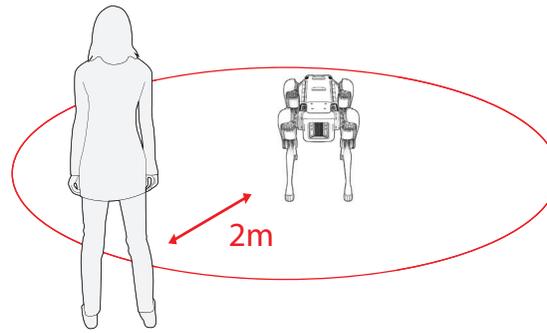
It is the operator's responsibility to ensure that **bystanders are trained in safe behavior around Spot**, and that the operation of Spot does not put anyone at risk.

SAFETY DISTANCE

Spot is not suitable for tasks that require operation in close proximity to people. **People must stay a safe distance (at least 2m) from Spot during operation to avoid injury.** Injuries may be caused by collisions, Spot falling or tipping onto people, or contact with Spot's pinch points.

Spot is suitable for areas where access is limited to trained personnel. Keep untrained people away from Spot during operation to avoid injury.

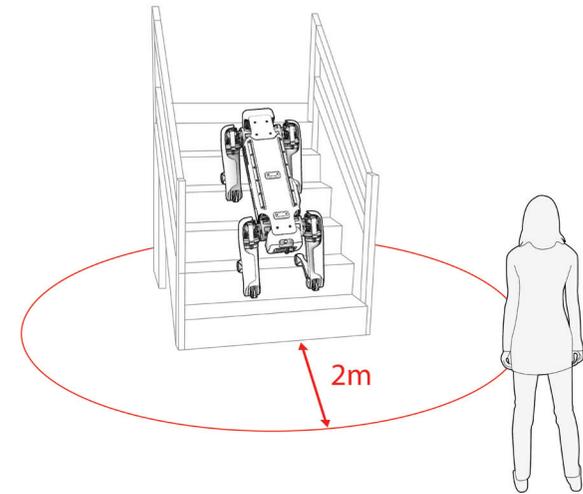
Spot may sometimes move unpredictably or fall. Only use Spot in areas where a fall or collision will not result in an unacceptable risk.



COLLISIONS

Spot can collide with people or objects, even with its obstacle detection system enabled.

- People around Spot should keep a safe distance of at least 2m from the robot while it is operating on level ground. Do not stand between Spot and a wall or other fixed object if this could violate the 2m safety perimeter.
- Do not operate Spot within 2m of delicate equipment or other property that may be damaged by the robot. Operators and anyone nearby should assume that Spot may move unexpectedly at any time.



FALLS

Spot may sometimes fall. Falls can damage Spot or the surrounding environment and injure operators and bystanders. Keep a safe distance of at least 2m from Spot while it is operating.

Never stand below Spot on stairways, elevated platforms, or inclines. For example, if Spot is at the top of a stairway, stay at least 2m away from the stairway bottom or any open areas on the side of the stairway and remain vigilant at all times to avoid a falling Spot. If Spot falls from an elevated position, it can cause serious injury or death.

The following conditions may cause Spot to fall:

Stairs or inclines	If Spot loses balance on the stairs or an incline, it may slip and fall.
Holes, elevated grounds, or cliffs	Spot cannot detect cliff edges and may walk off cliff edges that are unblocked. Block cliff edges with secure guardrails or safety netting. Never work below an elevated Spot.
Signal loss	If Spot loses its wireless connection to the controller, it will sit after 3 seconds, and the motors will shut off after 8 seconds. If this occurs on stairs, slope, or other uneven surface, Spot may slide or fall upon attempting to sit.
Slippery surfaces	Spot has difficulty walking, and may fall, on slippery surfaces. This includes surfaces made slippery by sand, dust, and liquids, for example.
Cords	Spot cannot detect when its legs are entangled in cords, which may cause it to trip and fall. The entangled cord and anything connected to it may also be damaged.
Unstable objects shorter than 30 cm	Spot may not automatically avoid unstable objects that are fully or partially less than 30 cm above the ground, such as human feet and backpacks, and may fall upon stepping on such objects.
Transparent, mirrored, or very bright obstacles	These can confuse Spot's obstacle detection system.
Moving surfaces	Spot can become unstable on moving surfaces, such as elevators, escalators, moving walkways and ramps, vehicles, or boats. Put robot in lockout mode when transporting on moving platform.

SAFETY IN HANDLING

PINCH POINTS

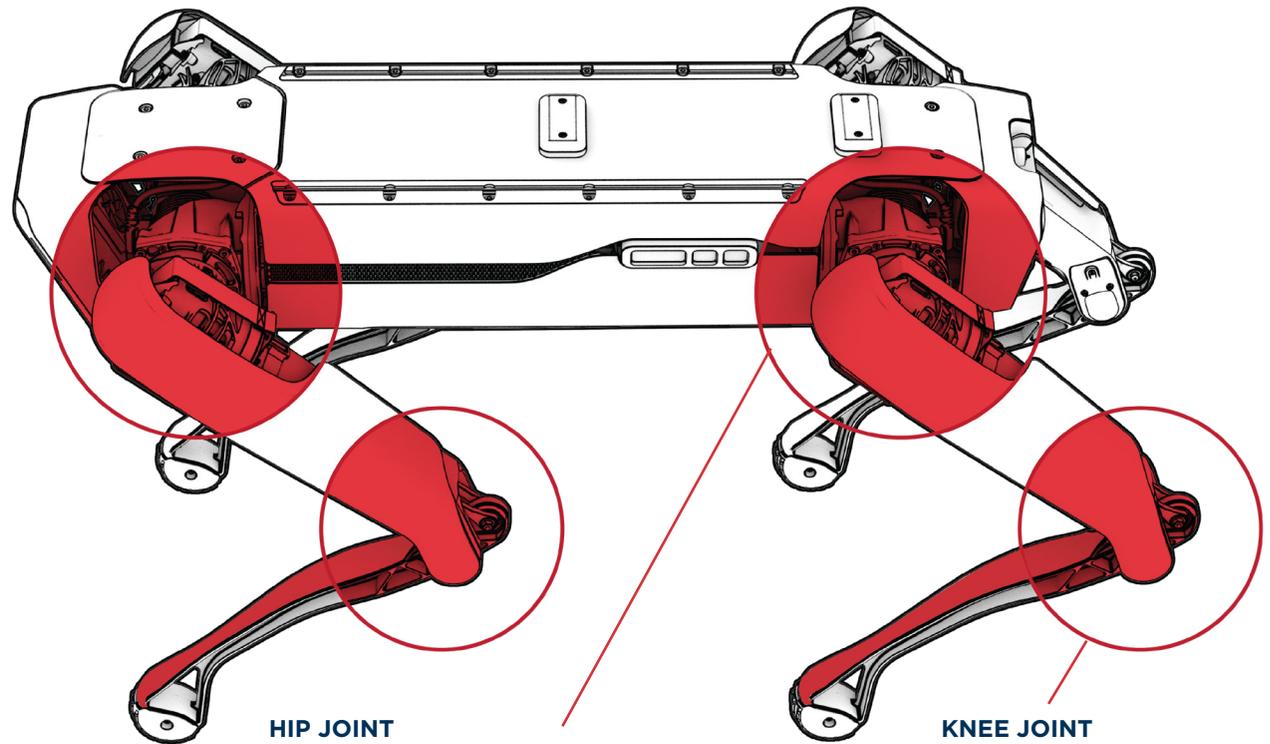
Spot's joints can pinch fingers and other body parts and entangle loose clothing, long hair, and jewelry.

Only handle Spot when the motors are locked out (see page 14) or robot power is off.

ACTIVE MOTORS

Fingers may break or get amputated if caught in joints while Spot's motors are active. Stay at least 2m away when Spot is powered on (except to press the lockout or power buttons).

1. Never touch Spot when motors are active. Stay at least 2m away at all times.
2. Before handling Spot, engage lockout to ensure motors can't turn on.



HIP JOINT

Always keep hands away from hip joint, except when grabbing handles. Always make a fist when gripping handles to keep your fingers away from pinch points.

KNEE JOINT

Always keep hands away from knee joint. Use caution when lowering Spot or closing the leg.

BATTERY SAFETY

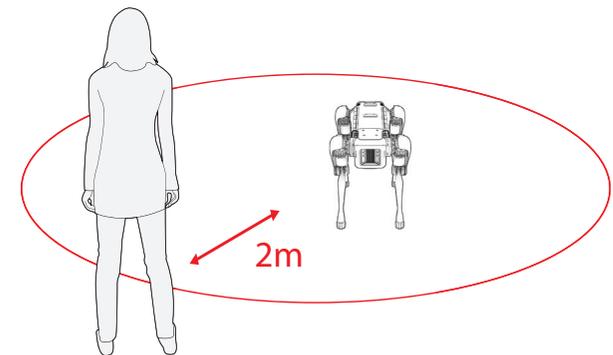
Spot is powered by a removable lithium ion battery pack. To reduce the risk of fire or electric shock:

- Only use the Spot battery, provided by Boston Dynamics.
- Only charge battery with provided Boston Dynamics charger.
- Don't short-circuit, burn, disassemble, submerge, puncture, crush, drop, or damage battery.
- If battery fire starts, don't try to put it out. Evacuate to a safe area and call fire department. Battery fires create toxic fumes and cannot be put out with conventional fire extinguishers or water.
- Store at -30 to 25C (-22 to 77F). Charge at 0 to 40C (32 to 104F). Operate at -20 to 45C (-4 to 113F).
- Spot operators should develop a battery storage and charging safety policy consistent with industry standards and local regulations.
- Remove battery from robot during transportation or storage.

BYSTANDER SAFETY

The operator is responsible for ensuring that all people who may come into close proximity of Spot are aware of robot hazards and receive Spot safety training.

- Keep at least 2m away from Spot and avoid the robot's path.
- It can be difficult to predict which way Spot will move next.
- Anyone passing Spot during autonomous patrol should avoid its path and maintain a 2m distance between Spot at all times.
- Do not stand between Spot and wall if this could violate the 2m or greater acceptable safety parameter.
- Never stand downhill or otherwise below Spot.

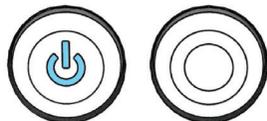


MOTOR LOCKOUT

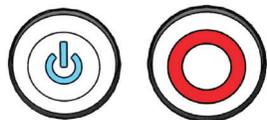
The lockout button mechanically disconnects the motor power and can only be activated by manually pressing the lockout button. Software cannot turn on the motors while the lockout is engaged.

To handle Spot safely, the robot must be placed in lockout mode. To enable lockout:

1. Turn motor power off with the controller.
2. Push the lockout button.
3. Confirm red light is off.



RED LIGHT OFF:
Motor lockout engaged.



RED LIGHT ON:
Motor not locked out; see all states for this button in **Lights** section on page 6.

It will be necessary to handle Spot when packing or unpacking for transport, replacing the battery, or righting Spot when it falls and is unable to self-right.



CAUTION: Never handle Spot unless motor lockout is engaged.

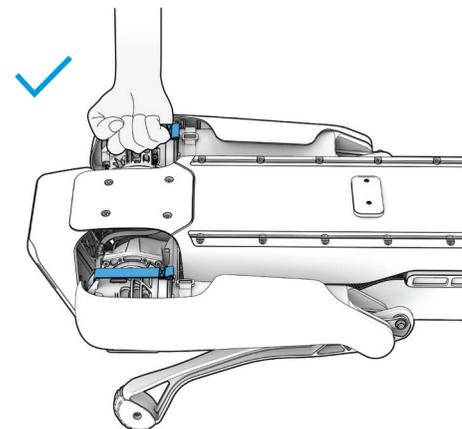
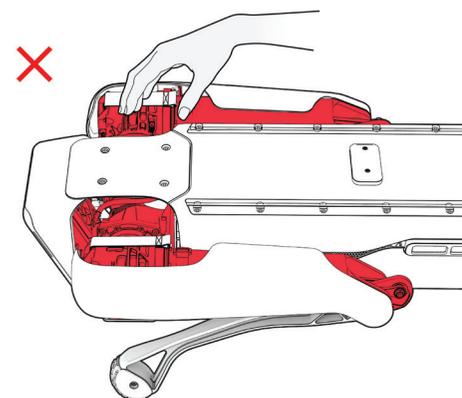
- Don't attempt to lift or move Spot while it is standing.
- Only move joints with motors in lockout mode or while Spot is powered off.
- Be careful to avoid pinch points

HANDLES

Spot has a handle at each hip joint. Use these to lift, carry, and roll the robot. When using the handles, always make a fist with each hand.



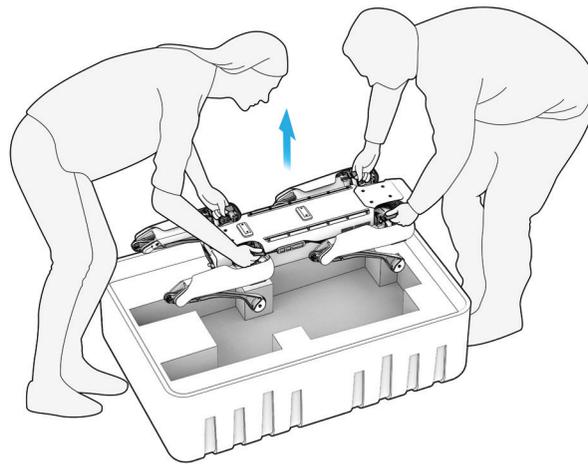
CAUTION: To avoid pinch points, never carry Spot with fingers extended.



HANDLING SPOT

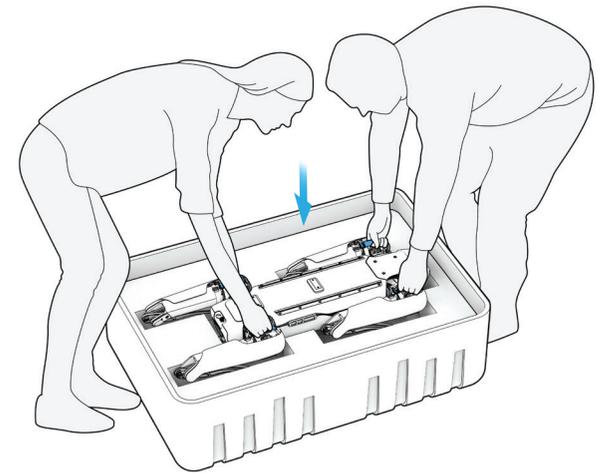
LIFTING SPOT

Spot is heavy (32 kg/70.5 lbs) and can be awkward to carry, particularly with attached payloads. Grab the handles and maintain safe lifting precautions. Always use two people to lift Spot, one at the front and one at the rear.



PLACING SPOT IN CASE

Remove battery from Spot. With two people, lift Spot by the handles and carefully lower into case.

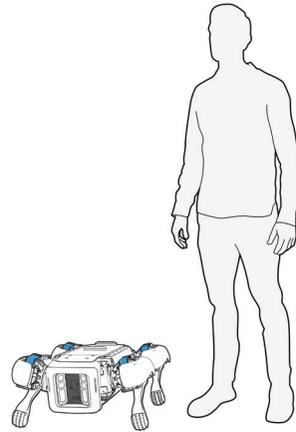


ROLLING SPOT

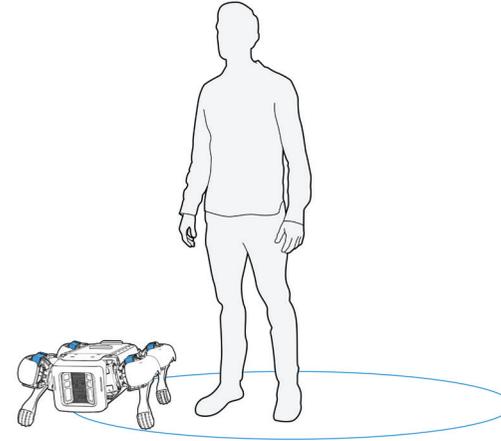
ROLLING SPOT ONTO ITS BACK



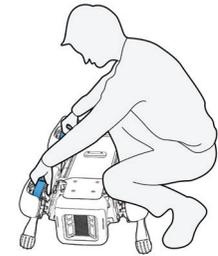
CAUTION: Always use Spot's handles when rolling the robot. Motors must be in lockout mode.



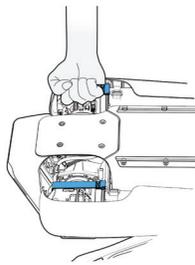
1. Stand to one side of Spot. Make sure motors are locked out.



2. Ensure that there's empty space to the other side.



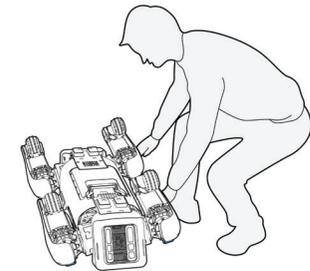
3. Grab farthest front and rear hip handles.



4. Close fists to avoid pinch points.



5. Lifting handles, roll Spot closer while moving backward.



6. Keep hands in a fist as Spot rolls.

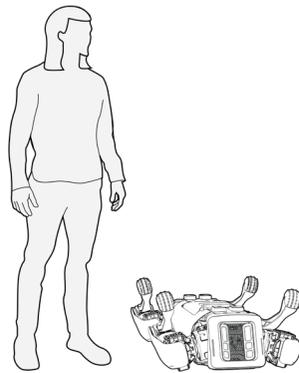
HANDLING SPOT

ROLLING SPOT INTO AN UPRIGHT POSITION

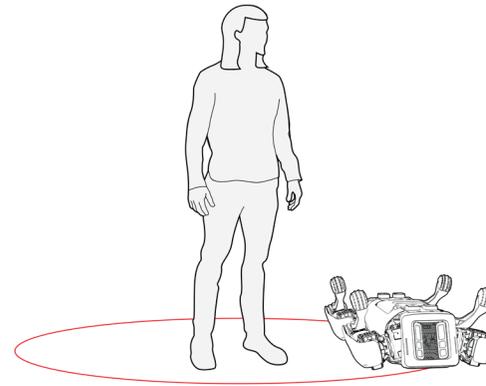
Spot can self-right on flat surfaces. Whenever possible, use the automated self-right procedure described on page 26.



CAUTION: Always use Spot's handles when rolling the robot. Motors must be in lockout mode.



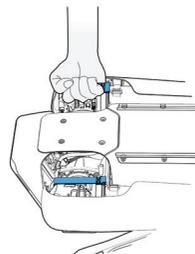
1. Stand to one side of Spot. Make sure motors are locked out.



2. Ensure that there's empty space to the other side.



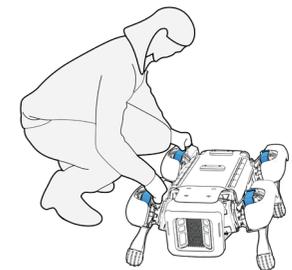
3. Grab farthest front and rear hip handles.



4. Close fists to avoid pinch points.



5. Lifting handles, roll Spot closer and move backward.



6. Keep hands in a fist as Spot rolls.

BATTERY POWER

Spot is powered by a removable lithium-ion battery pack. The battery can be charged stand-alone or while inside the robot.



CAUTION: To reduce the risk of electric shock and fire:

- Only use Boston Dynamics approved charger
- Use properly grounded outlet. Do not use ground adapters or replace plug.
- Do not touch uninsulated parts of output connector or battery terminals.
- Do not open or disassemble charger.
- Do not use if AC cord is damaged.

DETERMINING THE BATTERY LEVEL

The SOC button on the battery illuminates LEDs to show the battery level (state of charge).

Spot's controller shows the battery level in the Boston Dynamics app. The battery icon is in the info bar at the top of the screen.

BATTERY LIFE

Spot's battery provides power for about 90 minutes of normal operation and about four hours in standby (sit) mode. Payloads, high activity and computation levels, and low temperatures can reduce this runtime.

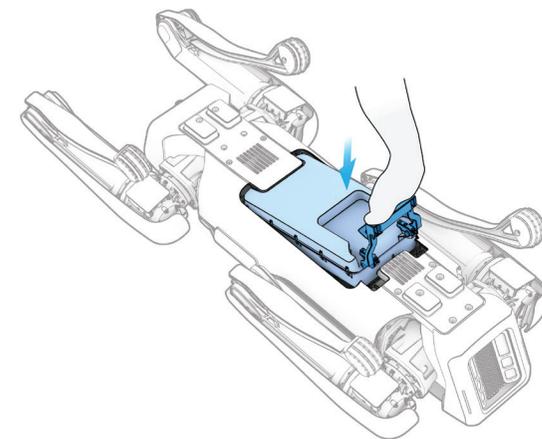
The battery should be removed from Spot if it will be unused for 72 hours or more.

INSERTING THE BATTERY

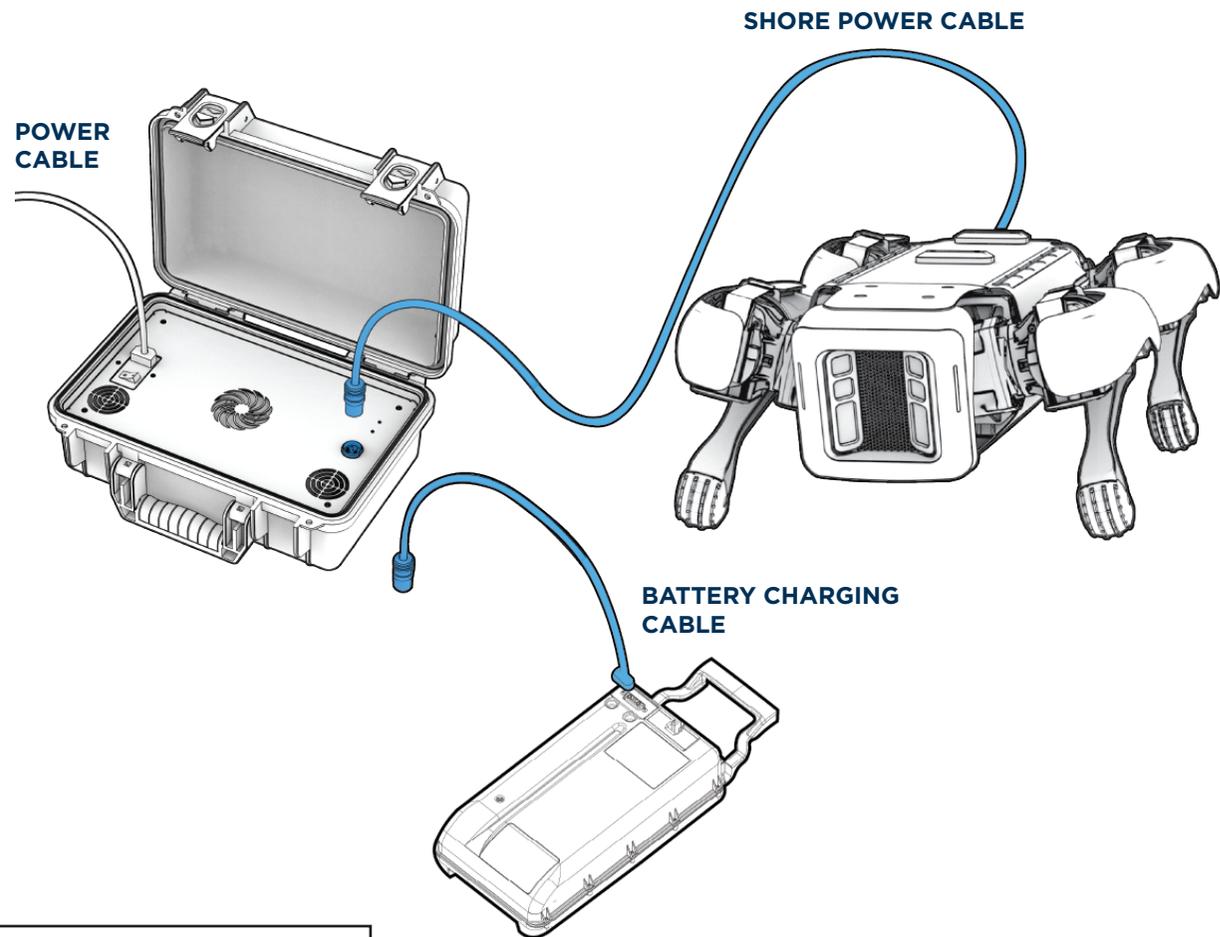


NOTE: Before inserting battery, document the information on robot label in battery compartment by taking a photo or recording the information. This information is needed to connect Spot to network.

With Spot on its back, slide the battery's non-handle side into the rear of Spot's battery compartment; latch the handle. Ensure the battery is properly latched.



SETUP



CHARGING SYSTEM

The charger comes with three cables:

- Power Cable: From charger to wall (AC)
- Shore Power Cable: From charger to Spot
- Battery Charging Cable: From charger to battery

Charging a standalone battery

Use the battery charging cable to connect the charger to a standalone battery.

The charger light will blink green while the battery is being charged and switch to solid green when the battery is fully charged.

Charging a battery in Spot

Use the shore power cable to connect the charger to the robot and charge a battery in Spot.

Carefully insert the charging cable into the charging port at the back of Spot shown on page 5.

The battery will begin charging regardless of whether Spot's computers are powered on or off.

The motors will not turn on while the power cable is inserted.

While charging, a port on the underside of the the battery may slowly blink red for a brief period. This is normal behavior.



NOTE: The cable only inserts one way, indicated with a white dot on the connector. Make sure the white dot faces down. Don't force the connector; inserting it at an off-angle can damage it.

CHARGER OPERATING ENVIRONMENT

Operating temperature: 0C to 40C

Input: 100-240 VAC, frequency 50/60Hz,
Current 5.5A Max

Charge time: Approximately 2 hours

Output: 35-58.6 VDC, 7.2 A Max

HOT-SWAPPING THE BATTERY

Hot-swapping is a way to exchange batteries without rebooting the robot's computers. To hot-swap:

1. Connect the shore power cable to the robot.
2. Replace the battery inside the robot with a fully charged battery
3. Remove the shore power cable.

This is a quick way to use Spot for periods longer than a single charge.



NOTE: Ensure that the power cable is inserted. Removing the battery without this will cut power to Spot's computers; they will shut down and may not save log or runtime data.

OPERATING ENVIRONMENT



WARNING: It's the operator's responsibility to only use Spot in a safe environment. These guidelines are for reference only. They don't describe every unsafe condition. If an environment or robot behavior seems unsafe: STOP.

ENVIRONMENT	YES	NO
Surface type	<ul style="list-style-type: none"> • Low carpet (recommended) • Clean dry pavement • Unwaxed clean indoor floors • Ram board-covered flooring • Grass • Packed dirt and sand • Gravel 	<ul style="list-style-type: none"> • Slippery surfaces <ul style="list-style-type: none"> - Wet grass - Ice • Entrapment hazards <ul style="list-style-type: none"> - Rebar mesh - Sideways ladders - Netting • Elevated platforms without proper safety barriers • Moving platforms such as vehicles or elevators
Space	<ul style="list-style-type: none"> • Clean open space • No objects or people in proximity to Spot • Stay 2m away from Spot when motors are active 	<ul style="list-style-type: none"> • Confined spaces without room for Spot to maneuver • Overhanging obstacles • Objects < 30 cm high that should not be stepped on • Thin objects < 3 cm • Glass or clear objects

OPERATION

ENVIRONMENT	YES	NO
Slopes	+/- 30 degrees	> 30 or < - 30 degrees
Stairways	Stair dimensions meeting US building code standards, typically 7" (18 cm) rise for 10-11" (25-28 cm) run	<ul style="list-style-type: none"> • Stairways with open sides • Stairways with people below
Climate	<ul style="list-style-type: none"> • -20C to 45C • Light rain 	<ul style="list-style-type: none"> • Anything outside defined ranges • Do not submerge robot in water
People	All people at least 2m away from Spot	<ul style="list-style-type: none"> • Untrained personnel onsite • Children onsite • People below robot operating on elevated ground • People on ladders or scaffolding near robot operating area
RF	Limited WiFi and cellular interference	<ul style="list-style-type: none"> • Conferences, sporting events, other environments where crowds and devices may interfere with operator's ability to control or monitor Spot • Unknown or poor communications performance

For conditions that may cause Spot to fall, refer to the Safety section on page XX for details on how to reduce the risk of Spot falling or colliding with people or objects.

TURNING ON SPOT

1. Make sure Spot:
 - Has charged battery
 - Is unplugged from power and ethernet
 - Power plug cover and ethernet cover are inserted
 - Is at least 2m away from people
2. Press and hold Power button for two seconds
3. Fans will turn on and spin loudly. Wait until fans turn off and status rainbow lights start blinking, approximately two minutes.



NOTE: Power and ethernet covers can block rear camera. Ensure they are properly seated before operating.

CONNECTING THE CONTROLLER

Spot has built-in WiFi. It hosts its own WiFi network and can join an existing network. Default usernames and passwords for Spot's WiFi are stored in the battery compartment. Payloads can expand Spot's connection options. Ask your system administrator for the preferred connection options for Spot.

1. Power on controller.
2. Open Boston Dynamics application.
3. Select the appropriate network as directed by your system administrator. For most initial configurations, this is Spot's built-in access point. To set up the network see the System Administration section on page 48.
4. Either select robot or add robot to network using "Add Robot."
5. Enter user name and password.
6. Select "Operate."

STOPPING THE ROBOT

REGULAR STOP

Press the controller's **B button** to stop Spot. It will pause and stand in place. If Spot is seated, it will remain seated. **In an emergency, use the emergency stop as described below.**

EMERGENCY STOP

Spot's Emergency Stop (STOP) provides a secure way to cut motor power. It takes priority over all other robot controls. When STOP is commanded, motor power is cut, causing Spot to collapse to the ground. Motors cannot be turned on until the STOP is canceled.

In an emergency, use the STOP option to halt Spot immediately, unless on stairs or other such position where a collapsing Spot would cause more harm than the failure to STOP the robot.

- Press controller **trigger buttons** and **B button** simultaneously.
- To immediately power off all motors, select red **STOP button** in controller's top right corner. Select Confirm.
- Spot will collapse to the ground.
- Motors cannot power on again until Emergency Stop is canceled. is canceled.



CAUTION: Emergency Stop makes robot collapse. **Emergency stopping Spot on stairs is dangerous.** Robot will collapse and may fall down stairs. Never stand below a robot on stairs. If Spot trips or is stopped it will fall down stairs and can injure anyone below it.

AUTOMATIC STOP

Spot monitors its sensors and can automatically pause movement or cut power in certain situations.

Signal loss: After 3 seconds without controller communication, Spot will sit. After 8 seconds without communication, Spot will turn off its motors.



WARNING: Losing signal on stairs could result in a fall. Use caution to ensure strong signals on stairs.

Smart freeze: When Spot detects a fall it will cushion leg movement to minimize damage from the fall.

TURNING ON MOTORS

Before turning on motors, release lockout button. Button light will pulse red.

Turn on motor power:

1. Ensure that no person is within 2m of Spot.
2. Announce loudly: "Power on Spot."
3. Turn on motor power using on-screen instructions in controller app.

SELF-RIGHT

Spot can sometimes end up on its back or on the ground with its legs in an unusual position. Self-righting flips Spot over and positions its legs to be ready to stand.



NOTE: Do not use self-right on uneven surfaces, slippery surfaces, or near other objects.

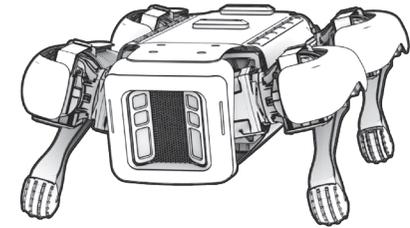
To self-right Spot:

1. Using the controller's action bar, press and hold "Stand" and then "Self-right."
2. Robot will attempt to roll over by moving its legs.
3. Robot will stop moving and then sit.

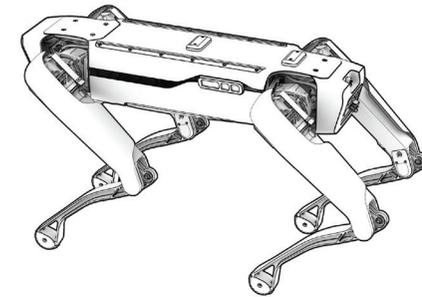
If Spot fails to self-right:

1. Turn off motors via controller app. Press **lockout button** on robot.
2. Spot's limbs will go slack. If Spot is upright or standing, it will fall.
3. Manually move legs and body into "sit" position, avoiding hip / knee pinch points.
4. Release **lockout button**.
5. Use controller to turn on motor power; attempt self-right maneuver again.

SIT & STAND



Press the **Sit** button to sit Spot on ground.



Press the **Stand** button to stand Spot in place.

OBSTACLE AVOIDANCE

Spot uses its perception system to automatically avoid running into obstacles. The perception system consists of five stereo cameras with a 360° field of view and a detection range up to 4 m.

To adjust how close Spot can get to an obstacle, move the Perception tab's "Avoid distance" slider to a distance between 0.1 and 0.5 m. Larger avoidance distances may prevent Spot from traversing doorways and other confined spaces.



CAUTION: Spot can collide with people or objects, even with its obstacle detection system enabled. Operators and anyone nearby should assume that Spot may move unexpectedly at any time. Only use Spot in areas where a fall or collision will not result in an unacceptable risk.

OPERATION

Demo: Obstacle avoidance

1. Place sample obstacle into demonstration area. Sample should be at least 50 cm on each side, with a minimum height of 50 cm, and resting on the ground. Never use people as obstacles!
2. Walk Spot towards the obstacle. Spot should avoid colliding with it.

LIMITATIONS

The following conditions can hamper the robot's obstacle detection system, which may result in collisions:

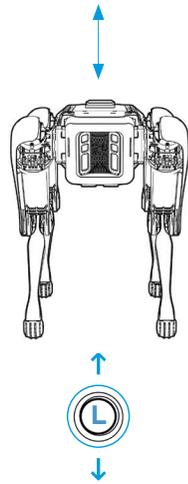
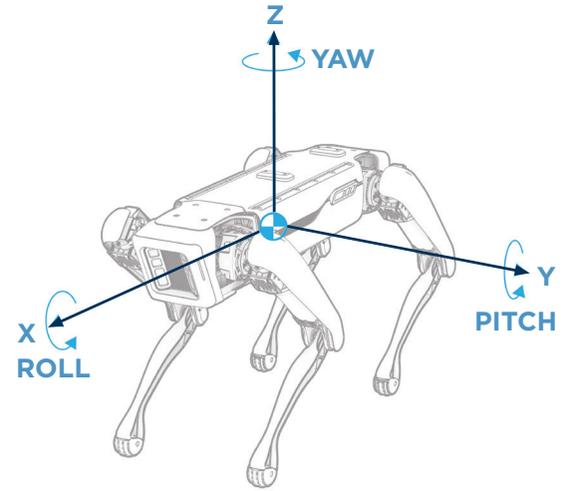
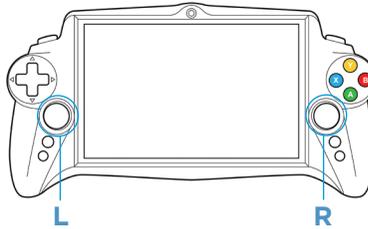
Very thin obstacles	< 3 cm in thickness. For example, ladders and tripods.
High contrast environments	Spot's perception system has difficulty with high contrast environments such as very black materials against very bright backgrounds.
Clear materials	Spot cannot see transparent materials and may crash into glass doors and windows.
Short objects	Spot may step on paint cans, buckets, and other objects shorter than 30 cm even with obstacle avoidance enabled.
Moving objects	Spot cannot predict trajectories of moving objects. Do not operate Spot around moving objects such as vehicles, children, or pets.
Elevated obstacles	Do not walk Spot under ropes, tables, scaffolds, or low-hanging but elevated obstacles. These can collide with Spot or its payloads.
Inadequate lighting	Spot requires sufficient lighting to function properly. Even in well-lit environments, shadowy areas may be too dark for Spot to detect obstacles.



NOTE: When walking Spot through soft objects like curtains, tall grass, or brush, it may be useful to turn off obstacle avoidance. However, Spot will now collide with all obstacles. It is up to the operator to avoid obstacles in this mode.

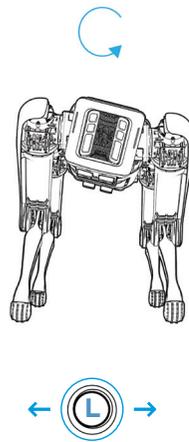
BODY POSING

The controller's joysticks can pose Spot's body while its in stand mode. Its feet will generally remain still. However, Spot may adjust its feet to maintain balance if necessary.



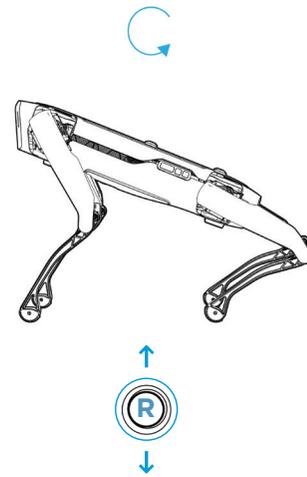
BODY ELEVATION

Y axis of left joystick moves body flat up and down



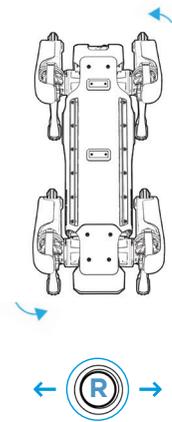
ROLL

X axis of left joystick rolls robot's body



PITCH

Y axis of right joystick changes robot's pitch (body angle)

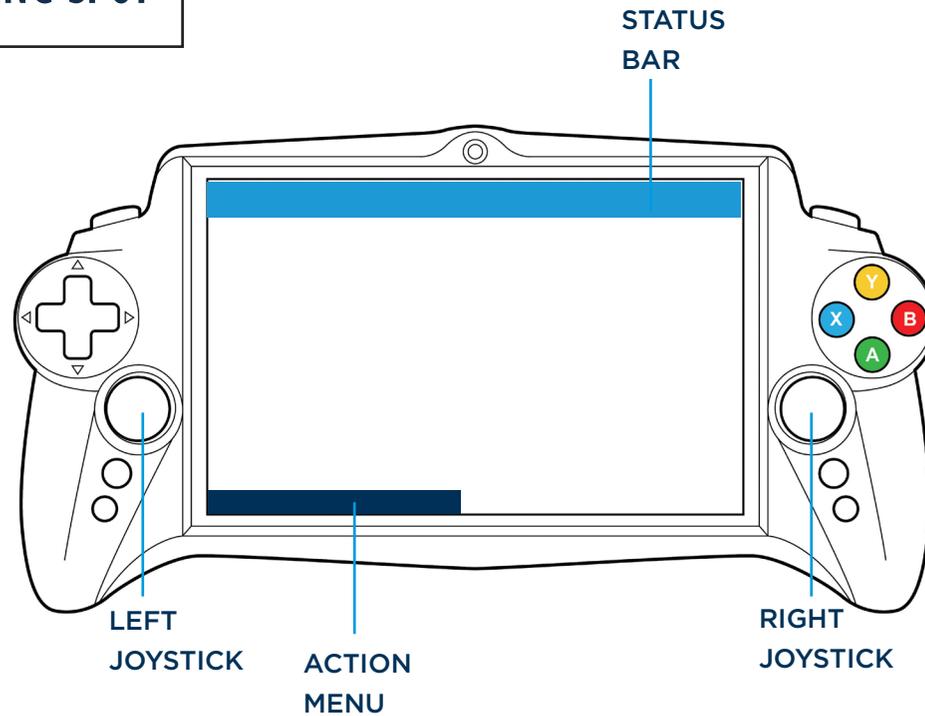


YAW

X axis of right joystick yaws nose left and right

OPERATION

WALKING SPOT



Spot can walk in most places that a person can. Only walk Spot in a safe operating environments as outlined in this user guide.

1. On controller app, select Walk from **action menu**. If Spot is sitting, it will stand up.
2. Use **right joystick** to turn Spot. This is easiest when standing behind Spot.
3. Use **left joystick** to move Spot's body. It can move forward, backward, right, and left.
4. To stop movement, release fingers from **joysticks**.

CHANGING SPEED

You can change Spot's speed by selecting options from the action bar. Beginners should stay at Slow speed. High speeds affect Spot's ability

CHANGING BODY HEIGHT

Change Spot's torso height with the controller in Pro mode. Changing height is useful for raising payload sensors to a greater height or to duck under obstacles. Spot will walk most stably when at 0 height (default). Other torso heights will degrade performance. to detect and avoid obstacles.

Demo: Mobility

1. Put Spot into Stand mode.
2. Demonstrate body posing.
3. Discuss how posing body enables better sensor and arm range.
4. Put Spot into Walk mode.
5. Walk Spot around in front of audience, keeping it at least 2m away from all people.
6. Switch gaits and demonstrate to audience.

STANDARD
MODE

Operational
gaits

DEMO
MODE

Demo gaits
(less stable)

CHANGING GAITS

Spot has multiple locomotion gaits. Change gaits to suit operating conditions of a mission or demonstration. The controller commands Spot the same way regardless of gait.

To change gaits:

1. Select “Walk” on action bar.
2. Select desired gait from pop-up menu.

GAIT	CHARACTERISTICS	BEST FOR
Walk	Dynamically stable movement	Walking around
Stairs	Slows Spot’s speed and pitches robot to better see stairs while descending	Climbing or descending stairs
Amble	Stable gait where one foot touches down at a time	Mobility demos, less stable
Crawl	Three feet touch the ground at all times	Walking on uneven terrain, most stable
Hop	Raises and lowers one front and opposite hind foot together for five counts	Mobility demos, less stable
Jog	Raises and lowers one front and opposite hind foot together	Mobility demos, less stable

TUNABLE PERCEPTION

Obstacle Avoidance	<p>Helps Spot maintain a minimum distance from obstacles</p> <ul style="list-style-type: none"> • In normal environments, obstacle avoidance should be kept on • In certain environments (such as outdoor areas with tall grass or foliage) Spot's performance may be improved by turning obstacle avoidance off
Walk on Grated Floors	<p>Improves Spot's performance on grated flooring</p> <ul style="list-style-type: none"> • To be turned on when Spot traverses on grated flooring • May also help Spot navigate flooring that has a very repetitive pattern
Ground Height Detection	<p>Helps Spot navigate over obstacles approximately 12" or less in height</p> <ul style="list-style-type: none"> • In normal environments, ground height detection should be kept on • When turned off, Spot is essentially blind, navigating only by contact • In certain environments (such as outdoor areas with tall grass or foliage) Spot's performance may be improved by turning ground height detection off
Stair/ Surface Edge Avoidance	<p>Keeps Spot from navigating too close to edges</p> <ul style="list-style-type: none"> • In normal environments, edge avoidance should be kept on • In certain environments (such as outdoor areas with tall grass or foliage) Spot's performance may be improved by turning ground height detection off
Plan Around Obstacles	<p>Spot allows extra margin around obstacles when using touch to go</p> <ul style="list-style-type: none"> • In normal environments, edge avoidance should be kept on

TUNABLE PLATFORM SETTINGS

Friction

Adjusts Spot's step height and speed for different surface types

- The lower the setting the slipper the surface
- Defaults to 0.6
- Lowering the value from default will result in slower and smaller steps
- If Spot is in good, dry conditions, his maximum speed can be achieved with the highest setting

Step height

Controls the height of Spot's step

- Three settings: Low, Medium and High
- Default setting is Medium
- If perception settings are OFF, Spot is essentially blind. Increasing the step height can help Spot navigate in this situation

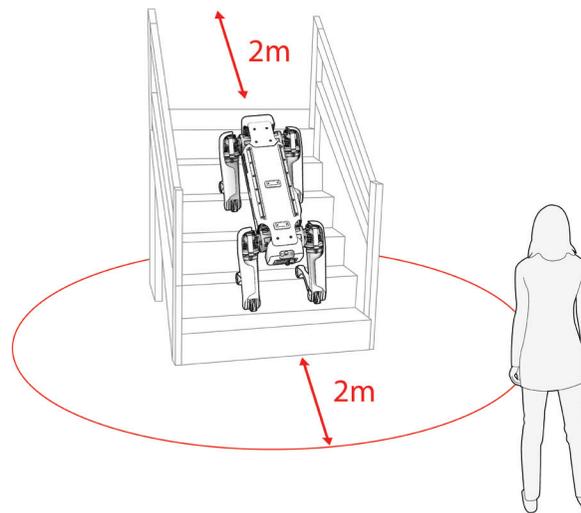
NAVIGATING STAIRS

Spot can navigate stairs:

1. Use controller to switch Spot to **stairs gait**.
2. Aim Spot up stairs.
3. Use left joystick to walk Spot up stairs, as if walking straight down hallway.
4. Always descend stairs with Spot in reverse. Always face Spot up the stairs.



CAUTION: Don't stand under Spot. Spot could fall, damage itself and stairs, and pose risks to others.



LIMITATIONS OF STAIRWAY NAVIGATION

- Do not use on grated stairs, open-riser stairs, or partially transparent stairways.
- Spot can only climb or descend stairs while facing up.
- Do not turn Spot while on stairs.
- Use caution when turning on landings.
- Never stand under Spot.
- Use caution when operating Spot near open railings; Spot can fall through shafts.
- Spot cannot climb stairs by side-stepping.

TELEOPERATION

Teleoperation allows operation of Spot beyond line of sight by displaying images from Spot's cameras on the controller.

RANGE

Spot's teleoperation range depends on communication and network configurations. If the controller is directly paired to Spot's WiFi access point, maximum range is typically 50 m. However, walls will affect this range, as will wireless network interference and other devices.

Placing Spot and the controller on a shared wireless network or using mesh radio or LTE payloads will enable longer-range teleoperation.

When Spot loses communication, it will sit down and turn off motor power.

SWITCH TO TELEOPERATION MODE

Press button labeled "Turn on Cameras" in top left corner; operator now sees what Spot sees in teleoperation mode.

CHANGING CAMERA VIEWS

Teleoperation primarily uses Spot's forward-facing stereo cameras. Use the D-pad or on-screen arrows to view side or rear camera footage.

DRIVE WITH JOYSTICKS

Joysticks and other operating features still function in teleoperation mode.

TOUCH TO GO

Touch to go lets you drive Spot to a specified location by touching the desired position on the camera image displayed on the controller screen.

- While in teleoperation mode, touch desired location on controller screen to make Spot go to location.
- Spot will go to location on ground plane; uneven terrain can cause it to overshoot or undershoot.
- Select X or B button to stop robot.
- Touch to go functions in various camera views. Choosing a location in Spot's rear camera will direct the robot backwards to that location.

AUTOWALK

ABOUT AUTOWALK

Spot's Autowalk feature enables you to record and replay autonomous behaviors with Spot. Autowalk consists of two parts:

- **Recording missions:** Drive Spot through a route and choose actions for the robot to complete at points along the way.
- **Replaying missions:** At the click of a button, Spot will execute the movements and actions as recorded, while adapting to minor changes in the environment.

MISSIONS

A mission defines Spot's movements and location-based actions in the environment. Missions can be used to automate repetitive tasks with Spot.

Spot tracks its position as it walks through the environment during mission recording. Spot will follow the same path during mission replay. If the environment changes between recording and replay, Spot will adapt its route to avoid obstacles and attempt to complete the mission.

Actions at specific locations can be added to the mission, to be executed when the mission is replayed.

Missions are recorded on Spot and are transferred to the robot controller when saved.

NAVIGATION

Spot compares data from its sensors with saved data in the recorded mission to autonomously navigate through the environment during mission replay. Mission replay relies on at least one navigation fiducial and multiple waypoints defining the robot's path.

FIDUCIALS

Fiducials are specially designed images similar to QR codes that Spot uses to match its internal map to the world around it.

Fiducials are required:

- At the beginning of every mission
- In "feature desert" areas where there is not enough information for Spot's sensors to determine its location in the environment

Spot recognizes AprilTag fiducials that meet the following requirements:

- AprilTags in the Tag36h11 set
- Image size: 146mm square
- Printed on white non-glossy US-letter size preferably rigid sheets



NOTE: Spot recognizes fiducials of all sizes, but is calibrated to fiducials that are 146mm squares. Using fiducials that are not 146mm squares will cause Spot to perform poorly.

More information on AprilTags can be found at the University of Michigan April Robotics Lab:

<https://april.eecs.umich.edu/software/apriltag>

WAYPOINTS

Spot automatically places navigation waypoints along its path during mission recording. It walks from waypoint to waypoint during mission replay.

Waypoints are automatically placed:

- At 2m intervals along straight paths
- When either event occurs within a 0.3m path segment:
 - Spot turns more than 30 degrees
 - Spot's elevation changes more than 0.3m
 - A mission action is recorded.

The base Spot platform tracks visual features within 2m of the robot with its stereo cameras. If Spot is outfitted with a LIDAR, it can track features within that sensor's range, typically over 50m. The added sensing range of LIDAR enables Spot to travel farther from features and through more dynamic environments.

During mission replay, Spot calculates its position by comparing features in its current sensor data with features in the data snapshots taken at each waypoint during mission recording. Spot automatically compensates for deviations in its path and small changes in the environment, but large discrepancies may require operator intervention.

ACTIONS

Actions are triggered when Spot reaches specific locations in the environment.

Image capture actions can be used to take spherical photos with the optional Spot CAM payload. These actions are useful for documenting work progress on a jobsite and for performing operator rounds and readings in industrial facilities.

API callback actions are used to run third party code at specific locations in the environment. Client code can run on a Spot payload or on an external device connected to the robot over the network.

API callback actions are useful for developers who are integrating custom payloads such as laser scanners or other sensors.

LIMITATIONS

Autowalk is designed to be used under operator supervision. Be prepared to stop mission execution at any time.



CAUTION: Do not use Autowalk:

- On stairs
- On elevated platforms
- In areas with open holes, cliffs, or fall hazards
- Around people other than the operator. Autowalk is intended to be used after-hours in areas away from people.
- In dynamic environments where significant change is expected between mission recording and replay.

AUTOWALK SETUP

Before using Autowalk for the first time, make sure to follow these guidelines:

1. Plan the route Spot should follow through the space and decide where you would like to record mission actions. Remove obstacles that could interfere with Spot during replay.

A good mission path:

- Is free of obstacles.
 - Is through an environment that is unlikely to change significantly between recording and replay.
 - Has features Spot can identify within sensing range (2m if using the base platform).
2. Place a fiducial at the mission's starting location and anywhere on the mission route where there is not enough information for Spot to determine its position (such as long white walls).

PLACING FIDUCIALS

When placing fiducials, **be sure to:**

- Place one at the mission's starting location.
- Tape fiducials flat against a vertical wall, as securely as possible. If fiducials move after recording, the mission may no longer replay.
- Place them low on the wall. The top of the fiducial image should be at human knee height, 45-60cm (18-24") above the ground.
- Place them in a permanent location where they will persist for as long as you plan to replay the mission.

- Place them in areas which are feature deserts, for example a span of over 3m of featureless white wall.

When placing fiducials, **avoid the following:**

- Repeating the same fiducial multiple times in a single mission. Each fiducial in a mission must be unique, however the same fiducial can be used in multiple missions.
- Placing fiducials in areas with inconsistent lighting. Shadowed or unevenly lit fiducials can have unreliable detections.
- Placing fiducials so that they are backlit by a bright background, such as on a window.
- Placing fiducials where they will be blocked, damaged, moved, or removed.



NOTE: Areas with intersecting walls, corners, furniture, equipment, and other visually distinguishing features do not typically require a fiducial (unless the mission starts in that location). Using a LIDAR payload for navigation will reduce the number of fiducials required.

RECORDING A MISSION

1. Move Spot within sight of the starting fiducial and use the robot's platform cameras to ensure it can see the fiducial. All missions must start at a fiducial.
2. Tap the Settings menu icon and choose Autowalk > Record new mission.
3. Give the mission a meaningful name to help distinguish it from other missions. By default,

mission names are based on the date and time of creation.

4. Tap “Start Recording” to start the recording process. From this point forward, every movement you make with Spot, and every action you add to the mission, will be recorded. The mission will be played back exactly as recorded during mission replay.



CAUTION: When recording (or replaying) a mission, maintain the 2m safety distance from Spot. Not only is following closely behind the robot dangerous, but you may inadvertently block sensor data from being recorded or interfere with the robot’s sensors during mission playback.

5. Drive Spot on your desired route through the environment by using the controller joysticks or Touch-to-go.
6. Use the + on the controller screen to add actions to Spot’s current location. Select which action you would like to perform and (optionally) give the action an identifying name. Actions will be triggered at this location during mission replay.
7. When you reach the end of the route, stop recording and save the mission to the controller by tapping the download arrow.

ADDING A PICTURE TO A MISSION

If a Spot CAM payload is attached, you can add a Picture action while recording the mission to capture a 360 degree image using Spot CAM

1. During the mission recording process, tap the plus sign on the controller screen.
2. Tap Picture as the action type to add.
3. Rename the picture action as needed and tap

Create to complete the process.

ADDING A CALLBACK TO A MISSION

1. During the mission recording process, tap the plus sign on the controller screen.
2. Tap Callback.
3. Rename the callback as needed and tap Create to complete the process.

When the mission is replayed, the robot waits for off-robot code to perform an Answer Question RPC. This code may be running on a payload computer, such as the Spot CORE, or a remote host, such as a teleoperator’s station.

For an example of how to read the callback action’s name and use the AnswerQuestion RPC, see the `mission_question_answerer.py` example in the Spot SDK.

DELETING A MISSION

While mission files are generally small in size, the list of missions to choose from can quickly become long. You can delete mission data on the controller in one of two ways, as follows.

To delete a mission in the Spot app:

1. Navigate to the Playback Mission page in the Spot app.
2. Tap and drag the mission you want to delete to the left.

To delete mission files using the controller Files app:

1. Open the Files app on the controller and navigate to:
Internal Storage > Documents > bosdyn > autowalk.
2. Select and delete the applicable folder to remove the mission from the controller.

REPLAYING A MISSION

Recorded missions are stored on the robot controller. You can connect a controller containing recorded missions to any Spot in your fleet and replay the mission with any of your robots.

To replay a mission:

1. Open the Settings menu on the controller and tap to select Autowalk > Replay Mission.
2. Select the mission you want to replay.
3. The mission loads into memory. Large missions may take several seconds to load.
4. Localize the robot to the start point fiducial and tap “Initialize Mission.”
5. The robot carries out the mission, following the mission route to its end point.

To pause mission replay, tap the pause button. Resume by tapping the play button.

MONITORING A MISSION

The operator must monitor all missions by connecting the controller to the robot as an observer. This allows the operator to receive the robot’s video stream on the controller.



CAUTION: Spot should be supervised during Autowalk mission execution. The robot operator is responsible for the safe operation of the robot whether manually driving the robot or in replaying a defined mission. The robot and its surroundings must be carefully monitored to avoid dangerous situations. The controller must be continuously connected to the robot during operation.

SKIPPING PART OF A MISSION

During mission replay, the operator may choose to skip part of a mission. This feature can be helpful when trying to run a mission where an obstacle prevents the robot from reaching a waypoint associated with a recorded action.

For example: During mission replay you discover that a forklift has been parked on top of a waypoint where an image capture action has been recorded.

To skip part of a mission if an obstacle is blocking a waypoint:

1. When the controller prompts you to skip part of the mission, click the skip button to take manual control of the robot.
2. Walk the robot past the blocked waypoint.
3. Press “Resume” to skip the waypoint and continue the mission.

TROUBLESHOOTING

If you have trouble recording, saving, or replaying Autowalk missions, review the following information for solutions to common problems.

The robot is stuck

Symptom: Spot keeps trying unsuccessfully to find a path around an obstacle.

Possible causes: Spot becomes stuck when it encounters an obstacle that it can't navigate around in a mission. For example: a wall was constructed across the mission path after it was recorded, or a piece of equipment was moved into the path.

Solution: Take control of Spot, using the controller to navigate it around the obstacle and resume or abort the mission.

If the robot is manually navigated past an actionable mission item, a "Skip Part of the Mission" button appears on the controller, which must be used to circumvent inaccessible mission actions.

The robot is lost

Symptom: Spot declares itself lost, sits and powers down its motors, and asks the operator to intervene.

Possible causes: The recorded mission is out-of-date. Spot declares itself lost when it detects a significant difference between its perceived location and its apparent location on the mission route. On the controller, this may look as if the mission is veering away from the intended route.

Solution: Re-record the mission.

The option to start recording a mission doesn't appear on the controller

Symptom: When attempting to record a new mission, the controller doesn't offer an option to start the recording process.

Possible causes: No fiducial visible to the robot. To start recording a mission, the robot needs to localize to a fiducial as a start point reference.

Solution: Localize the robot by moving it close to a fiducial. When the robot sees the fiducial, the controller will present the option to start recording.

Mission recording stops suddenly

Symptom: The comms icon on the controller flashes yellow or red and the robot stops.

Possible causes: The robot's connection to the controller has been lost because of network instability, weak battery, or other factors.

Solution: Resolve the communications issue, recharge batteries.

When trying to select a mission, no missions are offered.

Symptom: When selecting a mission to play back, no missions are presented and the replay fails.

Possible causes: When recording a mission, if the process is not ended by saving and downloading the mission, no mission will be presented to the operator to replay.

Solution: Be sure to save the mission on completion. Re-record the mission and finish the mission download and save process to completion.



NOTE: Delete incomplete missions from your controller so they no longer appear in the list of missions to replay. See “Deleting a Mission” on page 42 for more information.

The robot stops and sits down during replay

Symptom: During mission replay, the robot stops, sits, and powers down motors.

Possible causes:

- The robot is lost
- The robot has lost connection to the controller
- The robot battery is nearly drained
- The controller battery has drained.

Solutions:

- Relocalize the robot to a fiducial on the mission.
- Recharge the controller battery using a standard micro-USB cable.
- Recharge or replace the robot battery with a fully charged battery and resume or restart mission playback.
- Move the controller closer to Spot.

The robot stops during mission replay

Symptom: The robot has lost its localization.

Possible causes: Something has changed in the recorded mission environment — a fiducial was replaced, moved, or removed, for example, or the environment has changed significantly since the mission was recorded (moved equipment, new construction, etc.).

Solution: Relocalize the robot to a fiducial on the mission.

Robot fails to replay a mission

Symptom: The robot starts but doesn't complete a mission.

Possible causes: Robots may not successfully follow a mission if the mission space has changed significantly since the mission was recorded.

Solution: Clear the mission route of large obstacles. Re-record the mission, if necessary.

Incompatible constraints error message

Symptom: This error message appears on the robot controller when attempting to replay a recorded mission.

Possible causes: A mission was recorded during which the robot did not have enough room to turn around backwards before traversing down a ramp or a step. The mission recording completed but on replay the error message appears.

Solution: Tap “Continue” to continue the mission. Tap “Abort” to halt the mission replay. Re-record the mission, checking to make sure the robot has enough space to turn around before descending.



CAUTION: Continuing the mission will cause the robot to descend steps facing forwards, increasing the risk of the robot falling.

TURNING SPOT OFF

1. Walk Spot to charging, storing, or transport location. Walk Spot instead of carrying it whenever possible.
2. Sit Spot.
3. Power off motors with controller.
4. Engage lockout button.
5. Power off robot by pressing and holding blue button at Spot's rear for two seconds.
6. Select controller's Disconnect option.
7. Take battery to charger or plug robot into power source.

SHIPPING

ROBOT

To ship Spot, remove the battery and load Spot and the controller into the case.

BATTERY

The Spot Battery is considered Fully Regulated Dangerous Goods by the International Air Transport Association (IATA). Air shipment of any Spot Battery is subject to UN3480 - PI965, Section IA, which is covered under IATA regulations (<https://www.iata.org/>).

It is your responsibility to ensure compliance with these requirements when shipping any Spot battery. Always check the full regulations and carrier requirements before shipping.

Notable requirements include:

- Batteries must be properly packed in a UN-approved container, labeled, and declared according to IATA Dangerous Goods Regulations.
- The battery state of charge must be $\leq 30\%$ of rated capacity.
- The weight limit per container is 35 kg.
- The battery may be shipped by cargo aircraft only.
- The shipment must be signed by a person certified in accordance with IATA Dangerous Goods Regulations.

TROUBLESHOOTING

Errors affecting Spot's operation will be visible on the controller. Controller icons turn yellow for warnings and red when serious errors occur. The robot's status lights will also flash orange to alert operators of any serious error.

To document errors, take a screenshot of the controller screen with the error dropdown menu selected.

TRY THIS FIRST

The robot operator may be able to fix certain errors by turning the robot off and on again.



NOTE: When the robot is cold, some functions may not work. Let Spot warm up to room temperature for an hour and then power it on.

CONTACT SUPPORT

If error persists after rebooting robot, robot needs maintenance, or other issues occur, contact robot support.

Email: support@bostondynamics.com

Include:

- Robot SN (located in battery compartment)
- Issue
- Repeatability of issue

STARTUP ISSUES

Robot won't turn on

- Press battery's SOC button to check battery level. If charge level is one or two bars (less than 40% charged), swap battery.
- If battery is too warm (due to charging or heavy use), robot won't turn on, even when fully charged. Swap in cool, fully charged battery.
- Remove battery and put it back in.

Motors won't turn on

- Check if Spot's legs are tangled or at extreme angles, then adjust Spot to even seated position and try again.

Perception won't turn on

- Turn robot off and on again.

SPOT SYSTEM

The Spot System includes the Spot robot, battery, charger, and operating control unit.

FCC COMPLIANCE

The devices in the system comply with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) The devices may not cause harmful interference, and (2) the devices must accept any interference received, including interference that may cause undesired operation.

The Spot robot and charger have been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

The devices generate, use, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of these devices in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.



CAUTION: The devices are not intended for use in residential environments and may not provide adequate protection to radio reception in such environments. Operation of these devices in a residential environment could cause frequency interference.

SUPPLIER'S DECLARATION OF CONFORMITY (SDOC)

47 CFR § 2.1077 Compliance Information

Unique Identifier

Spot Robot, US Model #: 02-040236-001, Japan Model #: 02-040236-002

Contains radio module, FCC ID: 2ATBY-NMDB, Telec #210-130916

Spot Battery, Model #: 02-036845-001

Charger, Model #02-044200-001

Operating Control Unit, Model #: S192K, FCC ID: 2ARQ6-S192

Responsible Party - U.S. Contact Information

Boston Dynamics Inc.
78 4th Ave.
Waltham, MA 02451

Telephone: 617.868.5600

FCC Compliance Statement

The devices listed comply with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) The devices may not cause harmful interference, and (2) the devices must accept any interference received, including interference that may cause undesired operation.

SPOT ROBOT

The Spot Robot is compliant with requirements under FCC Part 15B, CISPR 11 & CISPR 14.

RADIO

The Spot Robot contains a certified radio module with the following certification identifications:



LASER

The Spot robot contains 5 stereo camera systems that contain Class I laser projection system.

This product is classified as a Class 1 Laser Product under the EN/IEC 60825-1,

Edition 2 (2007) and Edition 3 (2014).



This device complies with US FDA performance standards for laser products except for deviations pursuant to Laser Notice No. 50 dated June 24, 2007.

US FDA Accession Number: 1910287-000



CAUTION: Tampering or adjustments to any of the laser components is not allowed and may result in hazardous radiation exposure. Use of controls or adjustments or performance of procedures other than those specified herein may also result in hazardous radiation exposure.



CAUTION: There are no service/maintenance, modification, or disassembly procedures for the stereo module and infrared projector. The user must either notify System Integrators or return modules before any failure analysis is performed. Do not attempt to open any portion of this laser product and the camera assembly. Invisible laser radiation when opened. Avoid direct exposure to beam. There are no user serviceable parts with this laser product. Modification or service of the stereo module, specifically the infrared projector, may cause the emissions to exceed Class 1. No magnifying optical elements, such as eye loupes and magnifiers, are allowed.

SPOT BATTERY



The Spot Battery conforms to DENAN's technical requirement.



CAUTION: Only for use in Boston Dynamics Spot Robot. Only charge with Spot Charger. DO NOT incinerate, disassemble, crush, or puncture.

DO NOT short circuit. Damaged battery or short circuit may cause fire.

DISPOSAL

Waste Electrical and Electronic Equipment (WEEE)



This symbol means that this product must not be disposed of with household waste. It is your responsibility to bring it to a designated collection point for the recycling of waste electrical and electronic equipment.

For more information, contact the local waste collection center or Boston Dynamics.



CAUTION: Each battery pack includes rechargeable lithium ion cells. Lithium is a highly reactive element which reacts violently when mixed with water, leading to possible battery leakage, smoke, and fire. Battery packs must be handled, stored and disposed of with care to prevent physical damage to the pack and to meet the environmental requirements specified.

SPOT CHARGER



CAUTION: If the external flexible cable or cord of this transformer is damaged, it shall be replaced by the manufacturer or their service agent or a similarly qualified person in order to avoid a hazard.



UL Japan

The Spot Charger has passed conformance testing with a Registered Conformity Assessment Body



The Spot Charger is UL60950-1 & UL62368-1 compliant.

RoHS



E487365



The Spot charger is for indoor use only.



The Spot charger is over voltage category 2.

SPECIFICATIONS

CATEGORY	SPECIFICATION	VALUE
Dimensions	Length	1100 mm (43.3 in)
	Width	500 mm (19.7 in)
	Height (standing)	840 mm (33.1 in)
	Height (sitting)	191 mm (7.5 in)
	Net weight	32.5 kg (71.7 lbs)
	Degrees of freedom	12
	Max speed	1.6 m/s
Environment	Ingress protection	IP54
	Operating temperature	-20C to 45C
	Slopes	+/- 30 degrees
	Stairways	Stairs that comply with US building code, typically with 7 in. rise for 10-11 in. run.
	Max step size	300 mm (11.8 in)
Power	Battery capacity	605 Wh
	Max battery voltage	58.8V
	Typical runtime	90 minutes
	Standby time	180 minutes
	Charger power	400W
	Max charge current	7A
	Time to charge	Approximately 2 hours
	Battery weight	4.2 kg (9.3 lbs)
Payload	Max weight	14 kg (30.9 lbs)
	Max power per port	150W
	Payload ports	2
	T-slot rail bolt size	M5 x 1.0
	Camera type	Projected stereo
	Field of view	360 degrees
	Operating range	4 m (13 ft)
Connectivity	802.11	Wifi
	Ethernet	1000Base-T



NEED HELP?

Email support@bostondynamics.com

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