

## INTRODUCTION

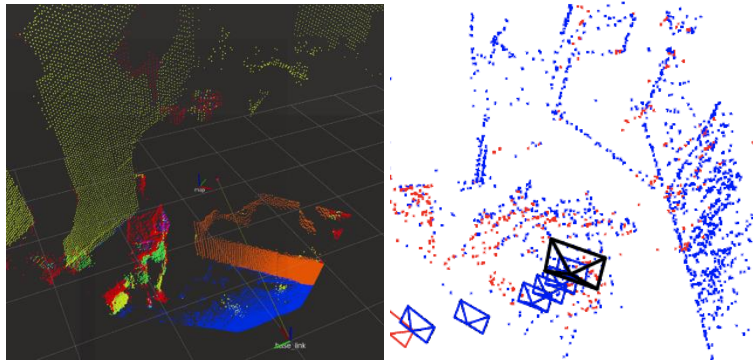
Astro is a new kind of home robot that combines innovations in Intelligent Motion, visual ID, and AI with Alexa to bring customers peace of mind and fun—whether at home or away. Able to proactively hang out in case it's needed, Astro is a part of the household and always ready to help out or entertain. Astro comes with Alexa to bring customers their music, calls, and more. Using the Astro app, customers can also see a live view of their home to check if they left their wallet on the kitchen counter or to check in on people or pets who are at home. Astro can even send notifications and alerts while customers are away.

To earn customer trust, we designed Astro and its experiences with privacy in mind by protecting customer data, whether it's stored locally or in the cloud, and by providing customers with transparency and control over their Astro experience. In this paper, you will learn more about how we've designed three new innovations introduced with Astro: Intelligent Motion, visual ID, and Astro's advanced home monitoring features. We describe how we built these features to protect customer privacy, such as by using Astro's on-device processing power. You'll also learn about how we've maintained our privacy-by-design approach with Alexa functionality on Astro. Learn more about Astro at [www.amazon.com/astro](http://www.amazon.com/astro).

## INTELLIGENT MOTION

Astro uses Intelligent Motion to autonomously and safely navigate the home and to adapt to everyday changes. It moves around objects, keeps a safe distance from people and pets, and stays away from stairs. Customers can ask Astro to follow them, go to a space in their home, or find a person in the household to deliver something. When not in use, Astro will return to the charger or hang out nearby in low-traffic areas in case it's needed.

*Images 1 and 2 – Intelligent Motion data for obstacle avoidance and navigation*

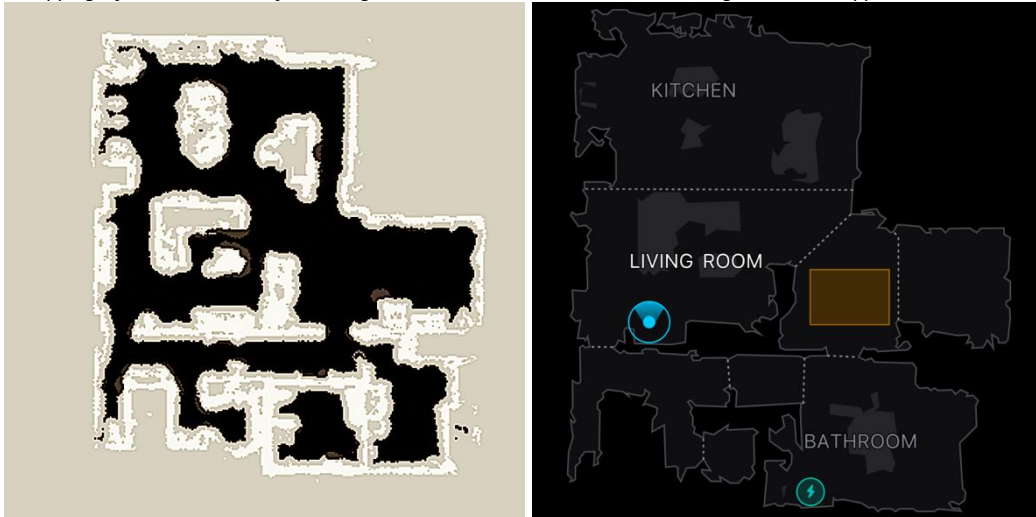


Astro uses information from its navigation sensors to recognize where it is and to detect nearby obstacles to avoid. The obstacle sensors use reflected infrared light and ultrasound to generate distance measurements to the floor or surrounding obstacles and to determine if there is a step down. The raw data from the navigation and obstacle sensors is locally processed into a distance measurement and discarded after processing, without retaining images or video or sending them to the cloud.

Astro sends information derived from its sensors to the cloud when it first explores a space or moves to a new room. This derived information includes data like the locations of walls, furniture, and objects. Amazon processes and combines this information with related data (like customer-provided room names, transitions between rooms, and readings of wifi signal strength) to create and store a map of the home in the cloud. Map data is encrypted in transit to the cloud, where it is securely stored with 256-bit keys, an industry standard for secure encryption. Astro requires the map to navigate.

In the Astro app, customers can view a rendering of the map. Customers can also use the Astro app to edit room names or boundaries, see where Astro is and to send it somewhere else, view information like a heat map of wifi signal strength, and create an out of bounds zone over an area it has explored if there is somewhere they prefer Astro not to enter. Using the Astro app, customers can delete this version of the map at any time. Customers who want to continue using Astro can create a new map by taking Astro back to its charger and going to Settings → Map Setup on the device.

Images 3 and 4 – Mapping Information derived from navigation sensors and its associated rendering in the Astro app, shown with an out of bounds zone



Astro tries its best to be a part of the household—and that means staying nearby in case it’s needed. Astro tries to hang out where it can be most useful based on factors like where it was recently used. Customers can always ask it to go somewhere else or say “Astro, go away.” Those who would prefer Astro not to hang out can disable the hangout feature in the device’s settings. Alternatively, customers can turn on the Do Not Disturb feature or set a Do Not Disturb schedule. When Do Not Disturb is on, Astro will only proactively find people to notify them of timers, alarms, and reminders. Customers can also use the microphones/cameras off button to disconnect the power to the bezel and periscope cameras, microphones, and navigation and depth sensors, which prevents Astro from moving or streaming audio or video to the cloud until the button is pressed again.

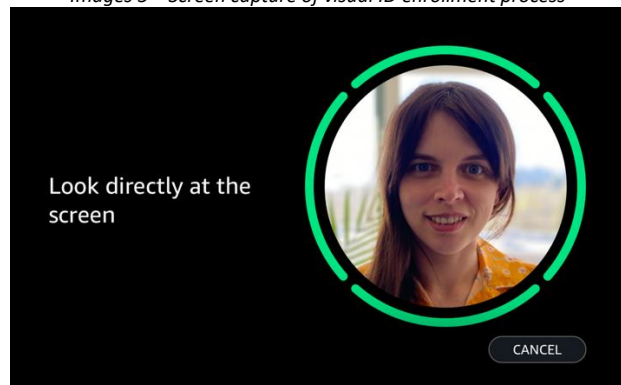
To learn more about Intelligent Motion, click [here](#) to read our science blog post.

### **VISUAL ID**

Astro comes with visual ID, an opt-in feature that enables Astro to provide personalized and proactive experiences for any member of the household who chooses to enroll. Once someone enrolls in visual ID, customers can see in the Astro app when that person was last seen by Astro, and Astro can do things like find that person to deliver a reminder or an item in its cargo bin, or initiate a Routine that is triggered when Astro sees that person. Astro can also send an alert if it detects an unrecognized person in the home when customers are away.

Visual ID uses on-device processing to recognize people who have enrolled. Astro does not recognize anyone other than the people who have created a visual ID. During visual ID enrollment, Astro will take a series of images from five different angles (straight, up, right, down, left). These images are securely stored and encrypted on-device and are not stored in Amazon’s cloud. They are used to create a feature vector—a numeric representation of the user’s facial characteristics—for each angle and to update the vectors over time to improve Astro’s ability to recognize that person. These vectors are also not stored in the cloud. Customers can delete the stored enrollment images and associated vectors at any time. We will automatically delete a user’s visual ID if Astro doesn’t recognize that person’s face for 18 months.

Images 5 – Screen capture of visual ID enrollment process



The visual ID system is trained with millions of images that were collected in studies with the consent of diverse participants. Once customers enroll in visual ID, Astro will attempt to match the visual IDs of enrolled users with individuals who walk into Astro's field of view. This matching process takes place locally and no images or vectors are stored in the cloud to provide visual ID.

To recognize a person, Astro first analyzes sensor inputs on a frame-by-frame basis to detect when a face appears in Astro's field of view. Astro processes each frame locally and does not send or store them in the cloud for face detection. During low-light conditions, Astro automatically turns on two red IR LEDs on the display to help detect and recognize faces even when it is dark. If a person walks into Astro's field of view who Astro does not recognize as someone who has enrolled in visual ID, the device will determine there are no matches to the stored vectors. The device does not retain images or vectors from unenrolled individuals after processing. When Astro detects a person in its field of view, it may send a signal to the cloud to provide enhanced features, such as initiating a Routine that causes Astro to display a greeting whenever it sees a person.

To learn more about visual ID, click [here](#) to read our science blog post.

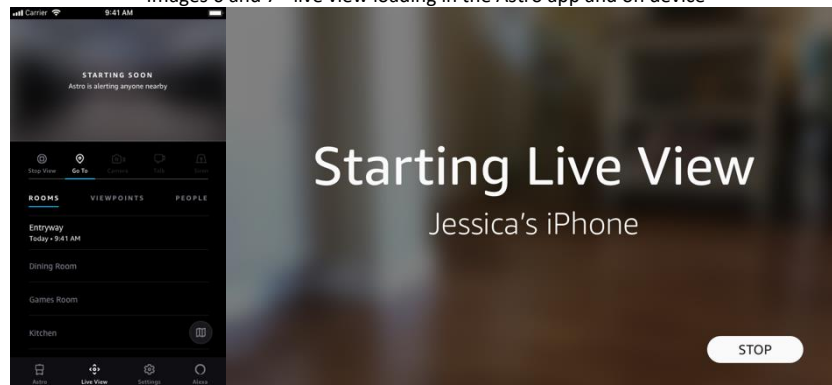
## HOME MONITORING

Astro provides peace of mind while customers are home or away with new home monitoring features, including live view, autonomous patrols, and investigations that enable customers to stay connected with the people, pets, and things they care about most in their home. While specific controls vary by feature, Astro's home monitoring experiences are all designed to protect customer privacy. These features and the controls we've built to protect customer privacy for each are explained in more detail below:

*Live View:* The live view feature allows customers to use the Astro app to see a live view of their home and check in on specific areas by sending Astro there. To set up live view, a customer must both sign in to the Astro app and pair their mobile device with Astro via a scan of a QR code shown on Astro's screen or via PIN code entry. Only an authorized mobile device can access live view in the Astro app to view Astro's camera feed and remotely control Astro. Customers can unpair a mobile device through Astro's on-device Settings to remove that mobile device's access to live view.

We designed live view so that users in the home are in control and aware of what is happening with Astro. For example, when customers start a live view in the Astro app, the device will show a visual indicator to notify people in the home that a live view session is about to begin. The person who initiates a live view session will initially only see a blurred view for a short duration (except when Astro is set to Away mode or actively investigating a detected event). During this time, people in the home have the option to cancel the video stream before it starts or end it after it has started, like by pressing the "stop" button on Astro's screen, or by saying "Astro, stop." Customers can also press the microphones/cameras off button to disconnect the power to Vesta's cameras, which will end any live view session in progress and prevent a new one from beginning. When live view begins, the indicator light on the top of Astro's periscope will be green to indicate that video streaming is in progress, and the screen will display a picture-in-picture view of what Astro is streaming. A live view stream is encrypted in transit between Astro and Amazon's cloud, and between the cloud and the Astro app.

Images 6 and 7 - live view loading in the Astro app and on device



Customers using the Astro app for live view can use the camera tab to record a video or take a photo, which are saved in the customer's Amazon Photos account. Photos and videos stored with Amazon Photos are encrypted, and can be accessed or deleted through the Amazon Photos mobile app (iOS and Android), or web app. For more information, click [here](#).

*Detecting events:* Astro has three home monitoring modes: Away, Home, and Disarmed. Customers can configure Astro to detect certain types of events when it is set to Away or Home, such as when an unrecognized person is present. Unless a customer has enabled the patrol feature, Astro will remain in a stationary position when it is set to Away or Home. When a selected event is detected, customers can receive an alert via a mobile notification that allows them to check in on their home using live view. When Astro is set to Disarmed, Astro will not detect the customer's selected events.

If customers use Alexa Guard with Astro, they can configure Astro to detect specific sounds, such as the sound of smoke and carbon monoxide alarms and glass breaking. Click [here](#) to learn more about Alexa Guard. Once enabled, Astro will only detect these sounds when set to Away and its mode will be synchronized with Guard's.

In addition, customers with a Ring Protect subscription and a linked Ring account can configure Astro to stream video to Ring's cloud storage if the device is set to Away or Home mode and a selected event is detected (the video stream will include a short duration from before the detected event). These videos are associated with the customer's Ring account, saved in Ring's cloud storage, and automatically deleted according to the storage period of the customer's Ring plan. Learn more about Ring Protect subscriptions [here](#). Customers can also review and delete individual video recordings in either the Astro or Ring apps at any time. For more information about how Ring's products and services are designed to protect customers' privacy, click [here](#).

*Autonomous patrols and investigations:* With a Ring Protect Pro subscription, customers can enable Astro's patrol and investigation features. The patrol feature enables Astro to periodically move through a customer's home when it is set to Home or Away, excluding Out of Bounds Zones. Customers can customize the frequency of patrol loops and choose to stream and save in Ring's cloud storage an encrypted 10-second, 360° video of each room Astro visits while on patrol. Astro automatically selects view-optimized scanpoints in each room, extends its periscope, and rotates in place to record these videos before moving to the next location. Astro displays a message on its screen and in the Astro app to let customers know what it's doing.

The investigation feature enables Astro to react to a customer's selected events by moving to get a better look and, if configured, streaming to and saving video in Ring's cloud storage. Astro can investigate events like sounds it detects through Alexa Guard, or events detected by a linked Ring Alarm system. If Astro can determine where the event originated, it will investigate by moving toward the source of the event—such as moving toward the location of an Echo device that detected the sound of glass breaking. In other cases, Astro investigates by performing a general loop of the home. If Astro is in Away or Home mode and recognizes a household member who has enrolled in visual ID, it will not begin an investigation and will instead ask if they want to set Astro to Disarmed.

### **Astro and Alexa**

Astro is Alexa-enabled, so it uses Alexa Voice Services to enable customers to ask questions and make requests using their voice. By default, Astro is designed to detect only the customer's chosen wake word(s), and no audio is stored or sent to the cloud unless the device detects the wake word. When Astro detects the wake word, or the customer uses the voice button in the Astro app, a visual or audible indicator will signal that audio is being recorded to stream to Amazon's cloud so we can process and respond to the request. As with other Alexa-enabled devices, customers can review and delete voice recordings by clicking [here](#). Click [here](#) to learn more about Alexa, including how customers can manage voice recordings associated with their account.

For more information about Astro and its capabilities, go to [www.amazon.com/astro](http://www.amazon.com/astro).