AWS RoboMaker

AWS Overview & Robomaker Introduction

6th Annual Entrepreneur's Forum and Technology Showcase
A Rising Tide - Organizing for Success
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Most Functionality

Use the right tool for the job!

Leverage the latest technologies to experiment and innovate more quickly.

Fastest Pace of Innovation

Largest Community of Customers & Partners

The AWS Partner Network includes thousands of systems integrators who specialize in AWS services and tens of thousands of independent software vendors (ISVs) who adapt their technology to work on AWS.

"There is no compression algorithm for experience"

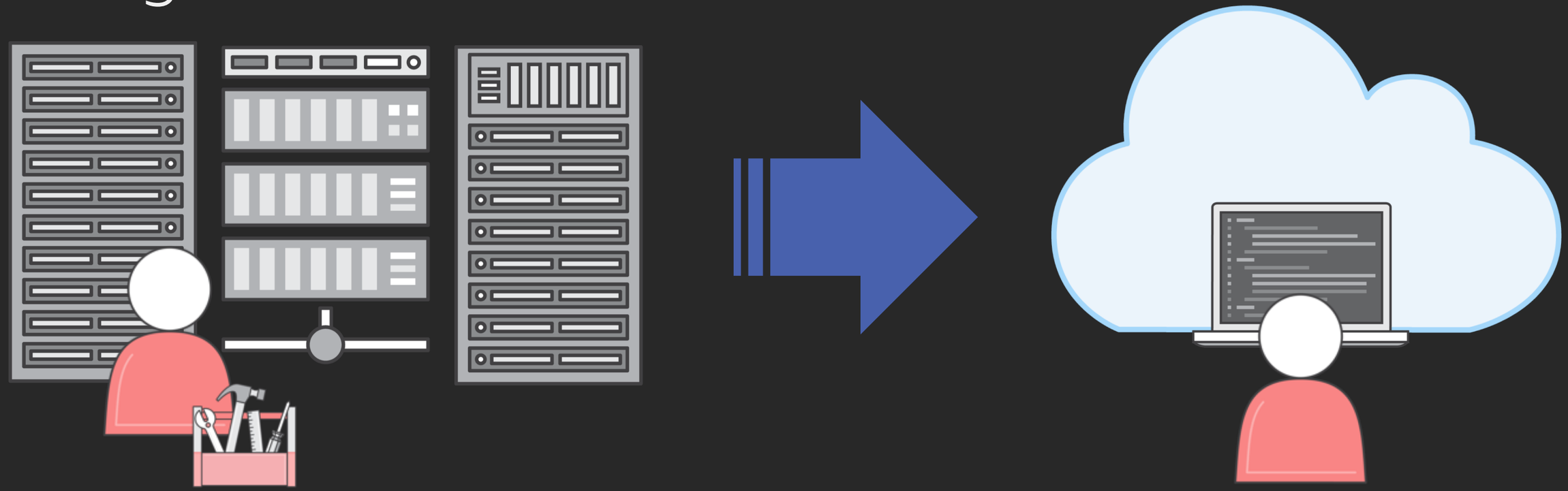
Andy Jassy – CEO AWS

Most Mature Cloud Platform

Most Secure Cloud Platform

AWS is architected to be the most flexible and secure cloud computing environment available today.

AWS has enabled on-demand delivery of computing power, database storage and other IT resources via the internet with pay-as-you-go pricing



Enabling Lean Startups with AWS Cloud

Zero upfront cost

With AWS's infrastructure-on-demand, startups can pay only for the resources they use instead of investing in servers upfront

Launch faster

Startups can have new IT resources available in just a few clicks, increasing agility

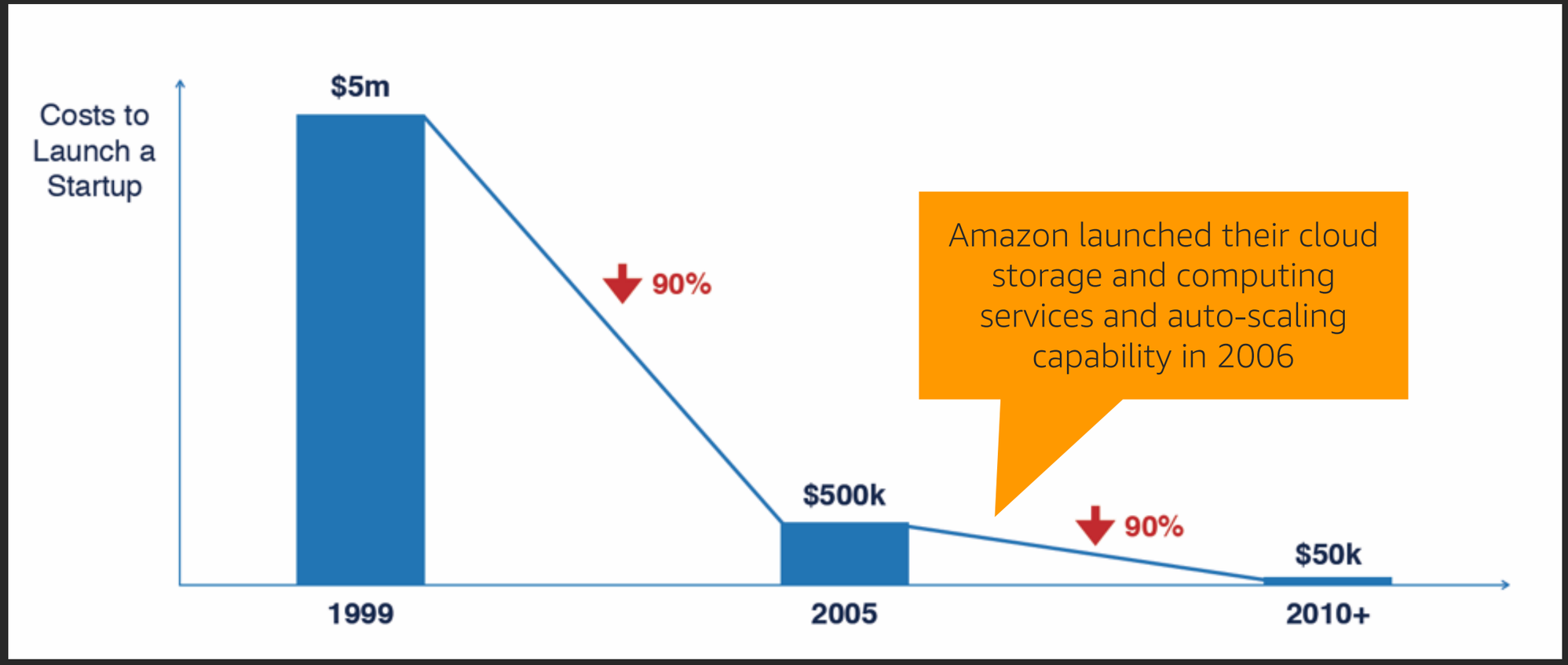
Focus on core business value

Startups can focus on growing their business rather than on infrastructure

Experiment often at lower risk

Being able to deprovision servers as needed enables startups to experiment often and fail fast if an idea doesn't work

Massive technology shifts such as cloud computing made it significantly cheaper to launch a startup:



Source: https://bothsidesofthetable.com/why-has-seed-investing-declined-and-what-does-this-mean-for-the-future-6a9572357130

AWS Startup BD: Working with venture capital and the startup ecosystem

We invest *indirectly* alongside venture funds and accelerators

We don’t

- Invest cash
- Take a capital position

We do

- Invest virtual currency (AWS credits)
- Invest time
- Share knowledge/experience/wisdom
- Help navigate AWS resources and support
- Open doors internally and externally
- Remove obstacles
- Leverage our global footprint
- Champion startups across all of Amazon
- Take a long-term view

We focus on helping our startup customers grow
by wiring them into people, resources, opportunities across Amazon

Technical

- Architecture design/optimization reviews
- Best practices
- Subject matter experts
- Betas/previews
- Security/compliance

Go-to-market

- Co-marketing
- PoC funding
- Sales referrals
- Distribution
- Capital intros

AWS RoboMaker

AWS Robomaker Introduction

Robot landscape

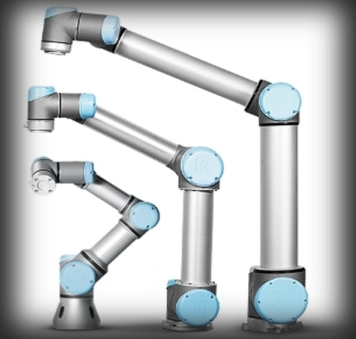
International Space Station

Tactical Ground Vehicles

UAV's

Self Driving Vehicles

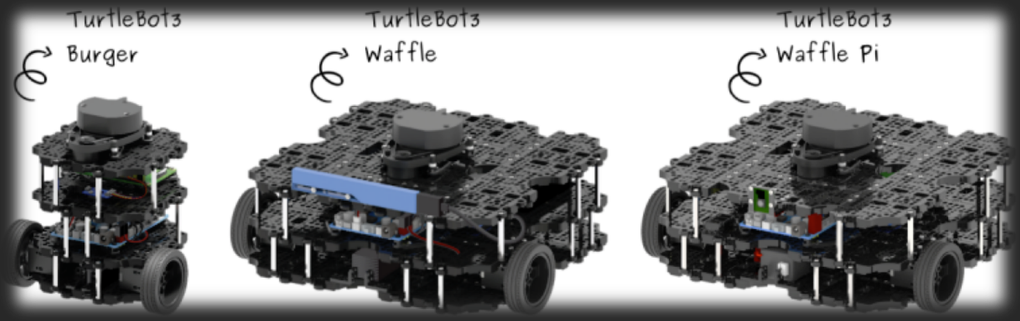
UUV/USV



Robotic Arms

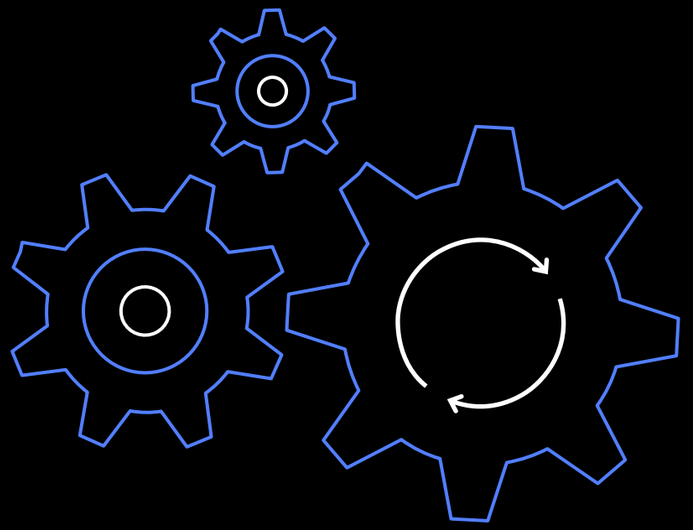
Mars Rover

Robotic Combat Vehicle (RCV)



Education

Robotics use is accelerating in key industries



Accelerated robot deployment in collaborative environments given enhanced capabilities such as autonomous mobility and artificial intelligence

By 2023, it's estimated that autonomous mobile robots will emerge as the standard for logistic and fulfillment processes

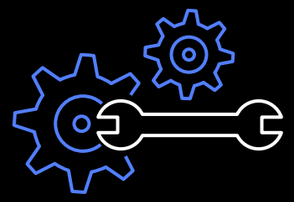
By 2030, 70% of all mobile material handling equipment will be autonomous

Source: IDTechEx

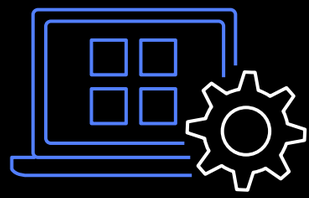
- Logistics
- Construction
- Retail
- Healthcare
- Consumer home
- Energy and utilities
- Oil and gas
- Public Sector

Challenges with robotics development and testing

Multi-domain expertise required to build robots



Iterative development to get it right



Configuration management is hard

Limited robot hardware available for testing

Deployment and updates need to be managed

The role of simulations

REPRODUCIBLE SCENARIOS

Re-create edge cases and unsafe conditions to test for unexpected behaviors

EXPANDED TEST COVERAGE

Programmatically run many scenarios that cover the vast majority of situations your robot would encounter

QUICKER RESULTS

Run tests faster than real-time for certain scenarios

Using simulation will increase development velocity, reduce the number of bugs and improve code quality.

Simulations at scale in the cloud

HIGHLY SCALABLE

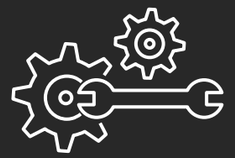
Concurrent simulations at cloud-scale via a single API call

HIGHLY RELIABLE

AWS cloud with enterprise-grade availability

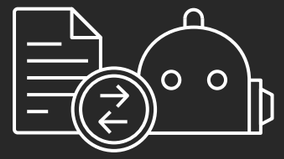
COST EFFECTIVE

Pay-as-you-go pricing lowers cost of product testing



FULLY MANAGED

Managed ROS and Gazebo software stack frees up engineering resources

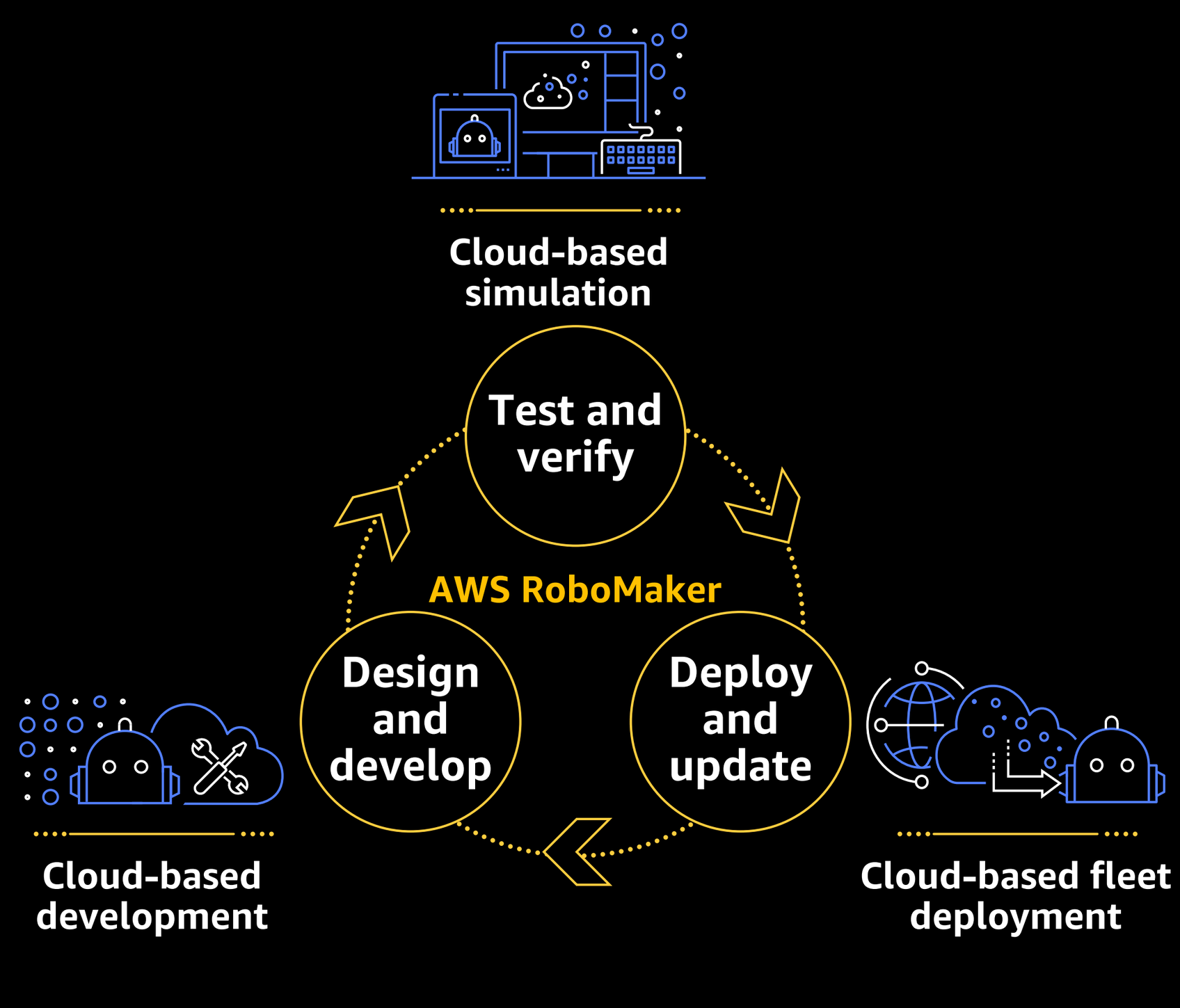


AWS SERVICE INTEGRATIONS

Suite of AWS services for building end-to-end solutions

AWS RoboMaker removes barriers to use simulation and enables automated testing at scale.

AWS RoboMaker: supporting the development lifecycle



AWS contributions to ROS2

Quality of Service (QoS) features for topics

Cross-compilation tools

ROS2 launch sandboxing extension

Secure-ROS2 (SROS2) improvements

Runtime analysis tools address & thread sanitizers (Asan/Tsan)

Created and maintain rcpputils core package

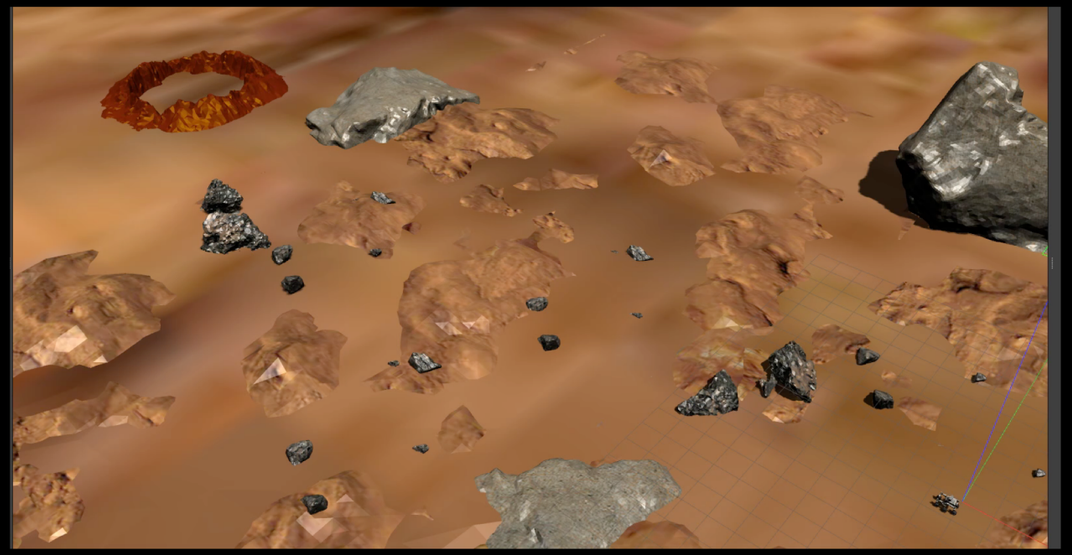
https://github.com/aws-robotics

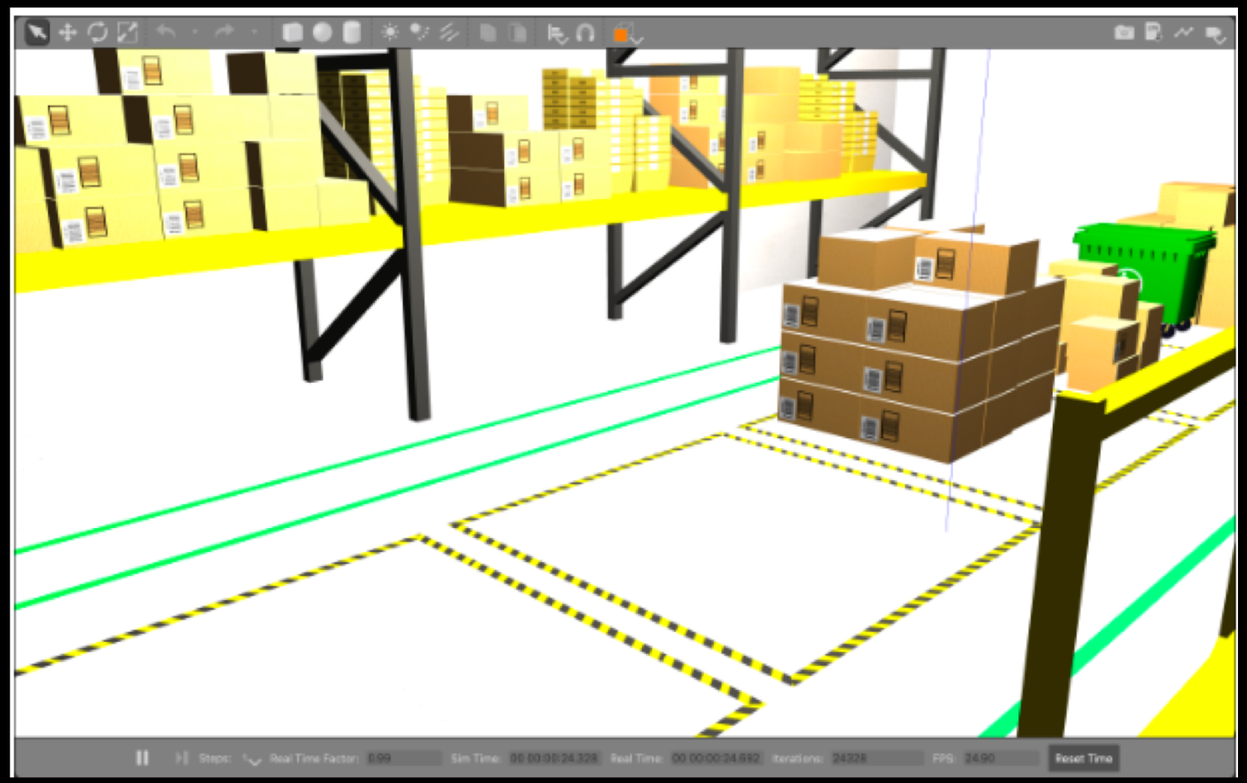
Design and develop: ROS and Gazebo

- Managed ROS* environment
- Support for ROS Kinetic, ROS Melodic, ROS 2 Dashing (beta)
- Managed Gazebo (Gazebo 7, Gazebo 9)
- Managed ROS/ Gazebo tools – rviz, rqt, GZ client
- Application and tool launch orchestration
- Batch simulation with API calls

*ROS: Robot Operating System

Generate a simulation world





Build a robot in simulation

Getting started

ROS urdf examples

ROS.org urdf packages

ROS Industrial Intro to urdf

CAD conversion to URDF*

SolidWorks to URDF

Solidworks to Gazebo

Blender plugin

Tutorials

ROS.org tutorials

Building a robot model

Visualize a robot urdf with rviz

*URDF: Unified Resource Description Format

Proposed program benefit: Implementation guidance

iRobot®

Customer Case Study

Concurrent simulations for regression testing with CI/CD integration

NEED

Increase code release velocity while improving test coverage for different floor layouts and scenarios.

CHALLENGES

Testing was costly and time consuming, therefore limited in coverage. Discovery of software defects happened late in the release cycle.

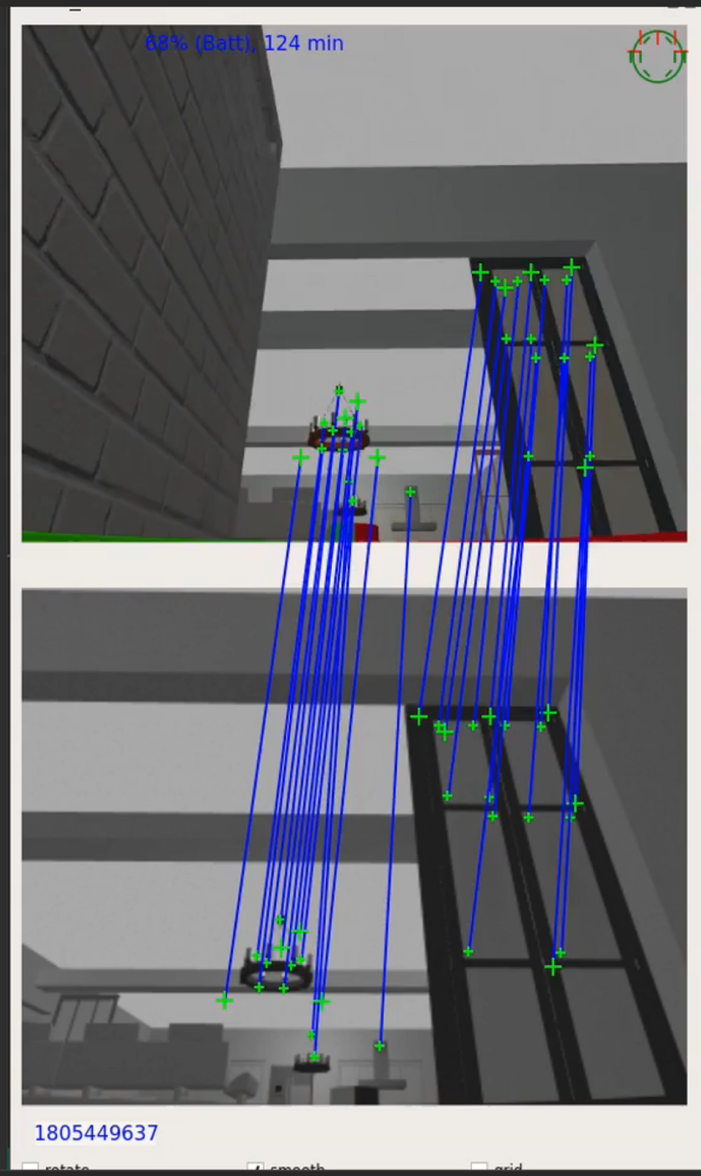
SOLUTION

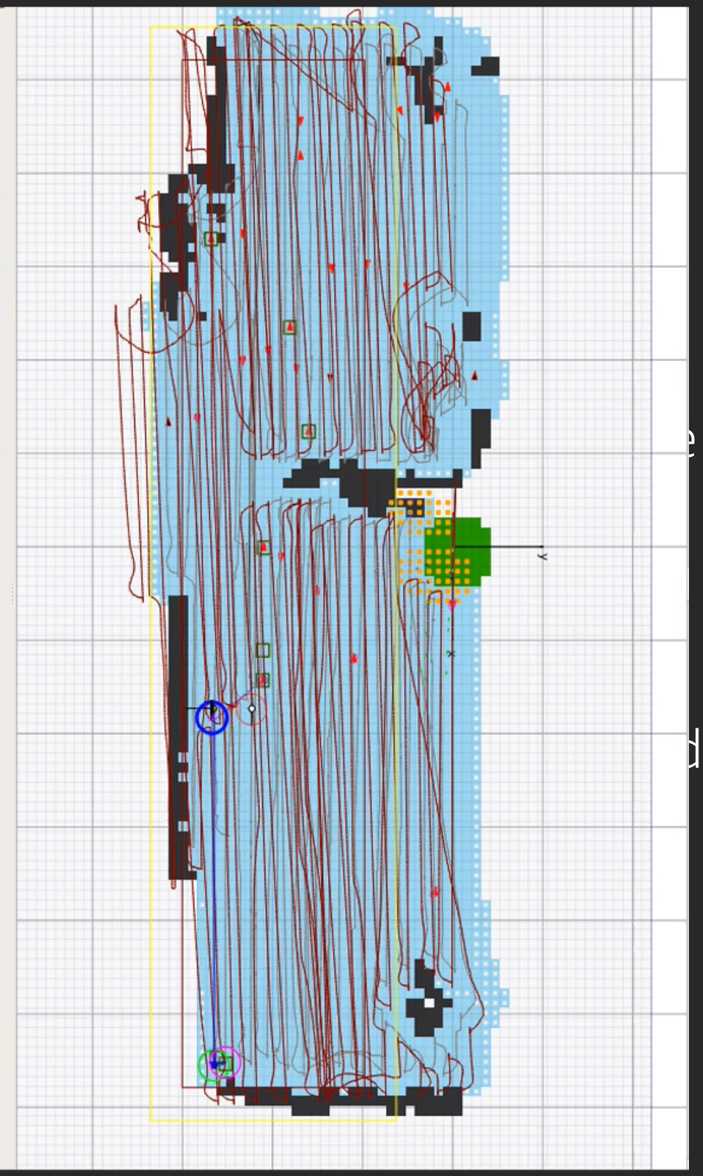
Automated simulation-based regression testing in a CI/CD pipeline using AWS RoboMaker, a fully managed cloud-based simulation service.

RESULTS

More than 40 automated tests on each code commit and more than 500 automated tests for each release candidate.

Regression testing with CI/CD integration





Design and develop:
ROS extensions, AWS integrations, Tools support

- Integration with AWS services enable easy ingestion of data from robots
- Native ROS packages for Amazon S3 for secure, scalable storage: Rosbag logging and upload to S3
- Integration with Amazon CloudWatch for easy logging and metrics collection
- Bundle your own GUI-enabled tools as part of robot and simulation applications

*ROS: Robot Operating System

AWS RoboMaker

ROS Application CI/CD Workflow
Application Architecture

Git Repository (GitHub or AWS Code Commit)

Branch: **feature**

Pull Request

Branch: **integration** ②

Branch: **master (release)**

①

ROS/ROS2 Development Environment

GAZEBO

ROS/ROS2 Simulation Environment

Clone on Git Hook (Merge)

AWS CodePipeline

AWS CodeBuild Build and Bundle Code in ROS Container ③

Bundles stored in S3

AWS Step Functions: **Testing**

④

AWS Lambda Simulation Launcher

AWS RoboMaker Simulation Service

AWS Lambda *Status Checker*

Describe Tags

Tests Passed

Clone on Git Hook (Merge) ⑤

AWS CodePipeline

AWS CodeBuild Build and Bundle Code in ROS Container

Bundles stored in S3

AWS Step Functions: **Physical Testing and Delivery**

AWS Lambda AWS RoboMaker Deploy Launcher

AWS Lambda Production Deploy Manual Action ⑦

⑥

AWS RoboMaker Fleet Management

1

Test Fleet

Prod Fleet

2

Learn more!

Read about **CI/CD, fleet simulations, batch simulations,** and more in the **AWS Robotics Blog**:

https://aws.amazon.com/blogs/robotics/

Get hands-on with **AWS RoboMaker workshops**:

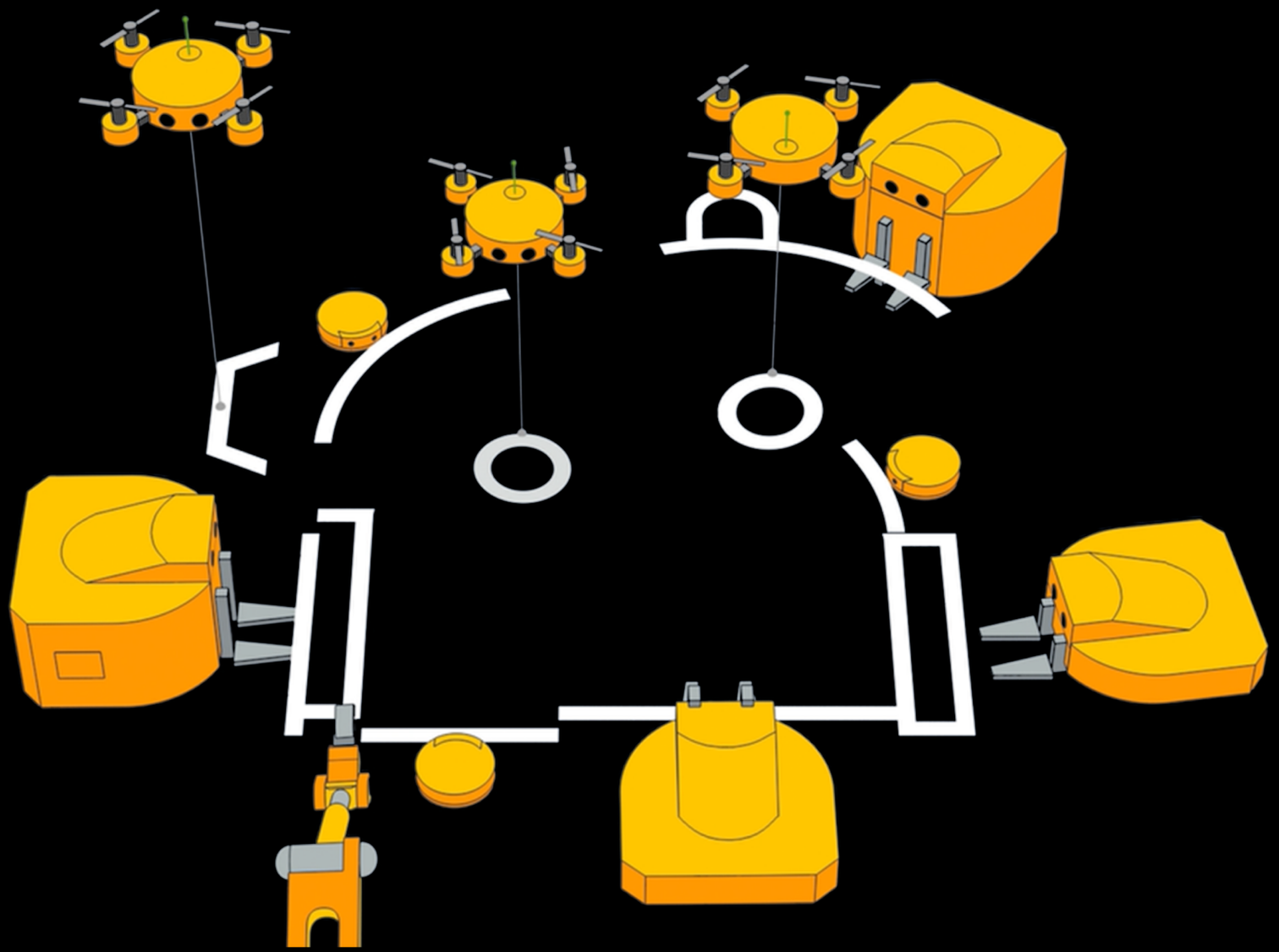
https://robomakerworkshops.com/

More details on **AWS RoboMaker:**

https://aws.amazon.com/robomaker

Try AWS RoboMaker today!

Questions?



Thank you!

Additional Information

RoboMaker Simulation JumpStart program

Process Steps	Simulation JumpStart Program components
1. Decide on test scenarios and simulation fidelity	Guidance on value of simulations and suitable test scenarios based on fidelity of the simulation environment
2. Build a robot URDF model	Documentation and guidance on how to create a URDF
3. Build a simulation world	Light-weight warehouse world under an open source license
4. Define test case	Definition of common test scenarios and test cases by category
	Sample test code for common test cases
	Whitepaper on testing best practices
5. Build testing definition	Sample test definition script
6. Build testing orchestration	Guidance on orchestration the test runs
7. Run simulations	AWS RoboMaker cloud service
8. Analyze test results	Guidance and best practices
Deployment support and Credits	Potential service offerings for building simulation assets and/ or simulation testing code
	Credits for AWS service usage

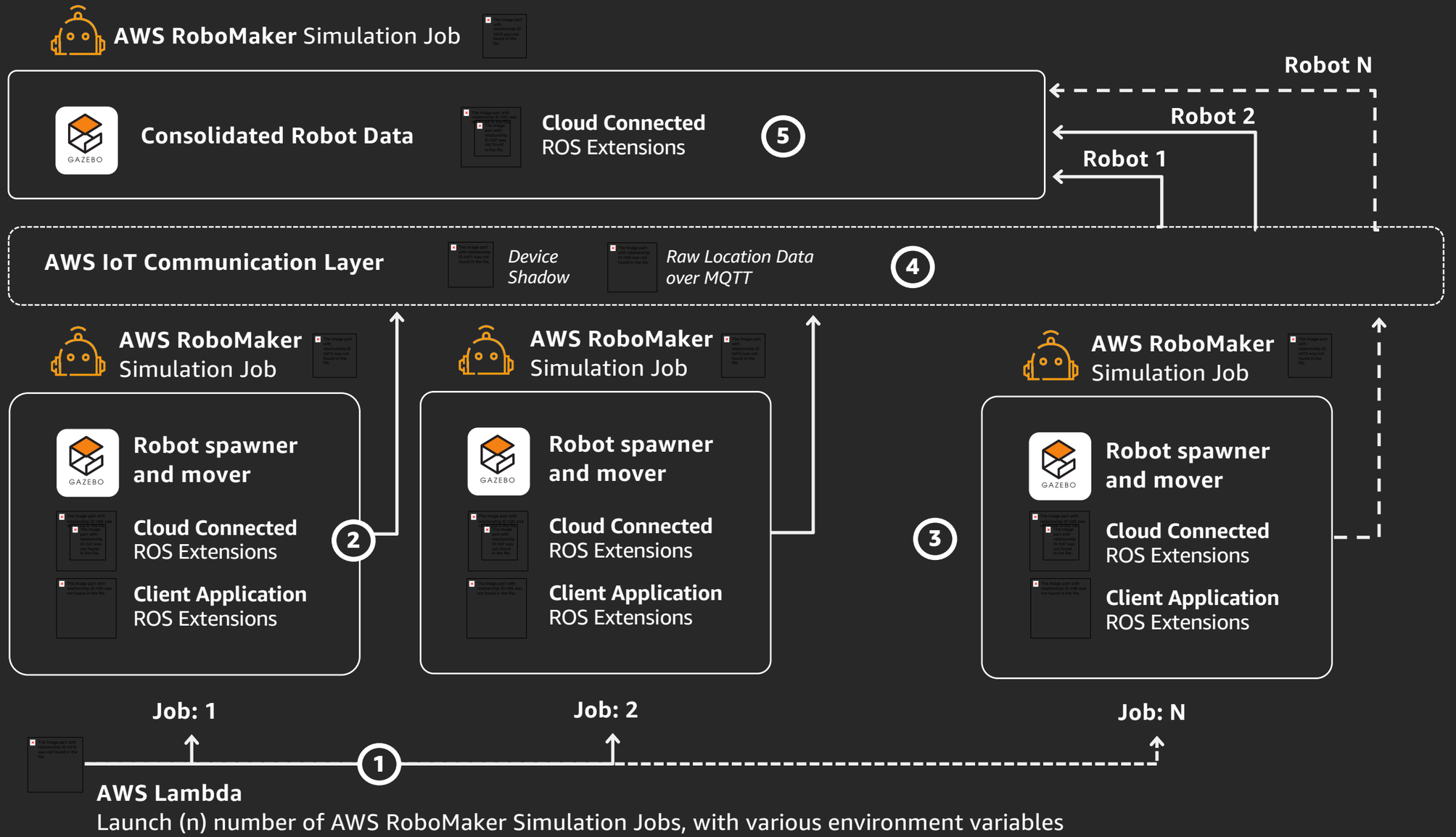
Note: Program is currently under Beta, available for select customers only.

AWS RoboMaker

1. Developers create feature branches for the user stories they are implementing. They work in a ROS development environment (IDE) of their choice.
2. When the developer completes their code, they submit a pull request to an integration branch. Once the code is reviewed, it is merged into the integration branch which invokes an **AWS Code Pipeline** job through a git hook.
3. The code is then copied into a **AWS CodeBuild** server, which is configured to use a custom Docker image with ROS build tools installed (based on ros:<version>). The build server runs colcon build and bundle commands, then uploads the bundles to an **Amazon S3 bucket**.
4. After the bundles are successfully in **Amazon S3**, an **AWS Step Functions workflow** is initiated to create **AWS RoboMaker simulation jobs**, monitor their progress and analyze the test simulation results. If the tests passed, the code can be safely merged into the master branch for deployment to physical robots.
5. The merge into the master branch invokes a new build process to prepare the robot application for deployment.
6. An **AWS Step Functions workflow** is used to manage the progress of the application code delivery. First, the production ROS application bundle is deployed to a fleet of test robots using AWS RoboMaker. Engineers will then review the physical test results, and if passed, advance the **AWS Step Functions workflow** with a manual action.
7. Conditions for production deployment (such as current battery life and location) as well as the number of concurrent deployments and failure thresholds are preconfigured in **AWS RoboMaker**. The tested, production ready code is now ready and is **safely and securely deployed** to the production fleet of robots.

AWS RoboMaker

Multiple Robots in Simulation
Application Architecture



AWS RoboMaker

1. An **AWS Lambda** function is used to parameterize and launch multiple simulations, each spawning a robot in an individual simulation job, but using the same Gazebo simulation world assets.

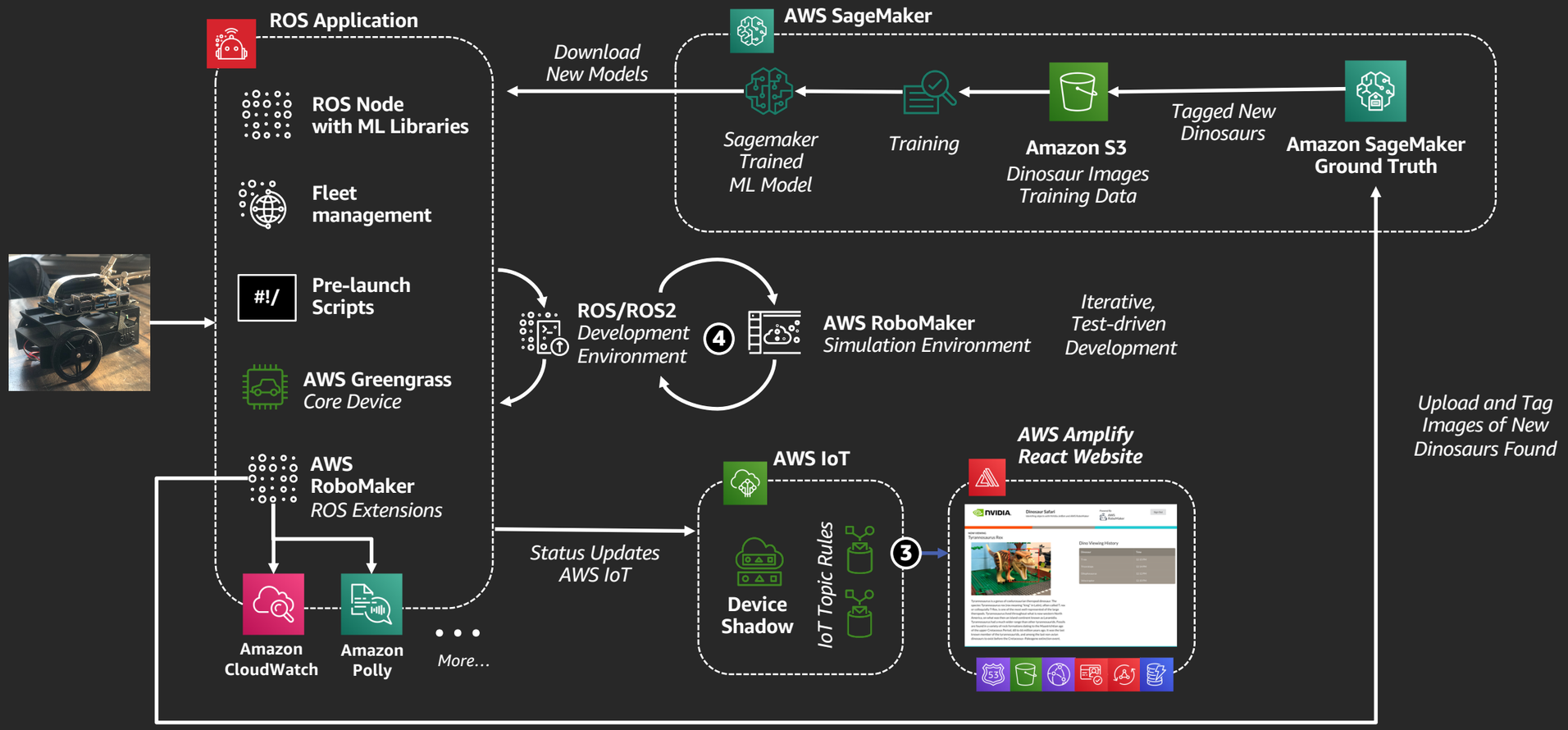
2. Once multiple simulation jobs are invoked, each individual robot is registered in **AWS IoT Device Management** and has an associated device shadow where robot state information (type and ID of the robot) is stored. As the robot moves, the telemetry data is published to an **AWS IoT Core topic over MQTT**.

3. The **AWS Lambda** function will spawn as many robots as defined, all publishing their state and location data to **AWS IoT**.

4. The MQTT message broker in **AWS IoT** is leveraged as a **many-to-one bridge** between the multiple simulations and a single, centralized and consolidated simulation.

5. The centralized ROS application running in **AWS RoboMaker Simulation** loads each device shadow and renders the robots in a consolidated view. This application subscribes to the telemetry topics and mirrors the robot shadow in the central application.

Robotics with Machine Learning



AWS RoboMaker

1. The **Robot Operating System (ROS)** application running on the **NVIDIA® JetBot** uses a local model, trained in **AWS SageMaker**, to identify dinosaurs in video frames as it explores a LEGO dinosaur world. The JetBot uses a small, powerful computer that runs in as little as 5 watts - the **NVIDIA® Jetson Nano™ Developer Kit.**

2. When a dinosaur is found, the application plays a short audio clip recorded using the **AWS RoboMaker ROS extension for Amazon Polly**, a text-to-speech service. A message with the dinosaur found is also sent to an **AWS IoT** MQTT topic.

3. An **Amazon CloudFront** and **Amazon S3** client-side front-end react web application, built using the **AWS Amplify CLI** tools, then receives the **AWS IoT** message and updates the dashboard.

4. New robot features are developed using a local ROS/ROS2 development environment or the **AWS RoboMaker** cloud-based IDE. During the development the new ROS code can be easily simulated in **AWS RoboMaker**.

5. Once the feature it is ready, the code is integrated into git automation processes that use **AWS RoboMaker** simulation service to test various scenarios. Then, the code is reliably deployed over-the-air (OTA) to production robot fleets using **AWS RoboMaker** fleet management.

6. As new dinosaurs are added to the LEGO world, they are tagged and uploaded to **Amazon S3** where a new model is trained in **AWS SageMaker** and then deployed to identify the new dinosaur.