AWS re:Invent

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ROB302

How cloud-based simulation is advancing robotics space exploration

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Agenda

About Lunar Outpost and its mission to bring payloads to the moon

Challenges for building robots that will run in space

How Lunar Outpost uses AWS to develop, test, and run robots in space

Deep dive on AWS RoboMaker and new features to run high-fidelity simulations in the cloud

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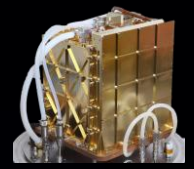
Lunar Outpost

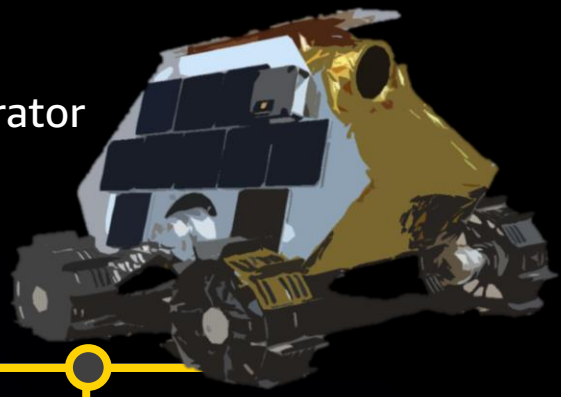
Enabling an extended presence on the lunar surface

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About Lunar Outpost







2017 Founded

2018 First product sold

2018 USAF Instrumentation contract

2018 First contract with MIT for MOXIE

2019 NASA Planetary Robotics contract

2019 AFRL Robotics contract

2020 USSF Robotics contract

2020 Canary collects 15 billionth data point

2021 BBC NEWS: Nasa to pay company . . . to collect rocks from moon (ARTEMIS)

2021 MOXIE creates oxygen on Mars

2021 AWS Space Accelerator with Seraphim

2022 Nokia

2023 MAPP to be the first rover on Lunar South Pole

Join us for **the next leap**

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Challenges when building robots to run in space

- Temperature extremes of the lunar surface
- No existing support infrastructure
- High radiation exposure over time
- Development challenges
  - Representative hardware is expensive
  - Physical trials are inherently risky
- Possibility for intervention (debugging) is limited once on the moon







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Mobile Autonomous Prospecting Platform (MAPP)



MAPP is the first debuted commercial lunar resource prospector

It's designed to be industry leading in payload mass ratio; it can survive the lunar night; and much more

Total mass: 10 kg

Payload mass fraction: 50%

Top speed: 10 cm/s

Dimensions: 45 x 38 x 40 cm

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Development with AWS

Amazon QuickSight

- Insight into improvement over time
- Visualize performance statistics for algorithm iterations acting in simulated environment
- Individual commits are available for analysis/comparison

AWS RoboMaker

- Agile iteration and testing
- High-fidelity simulated lunar environment
- Scalability
  - Swarms
  - Growing development teams can use simulated rovers

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Improving navigation stack over time



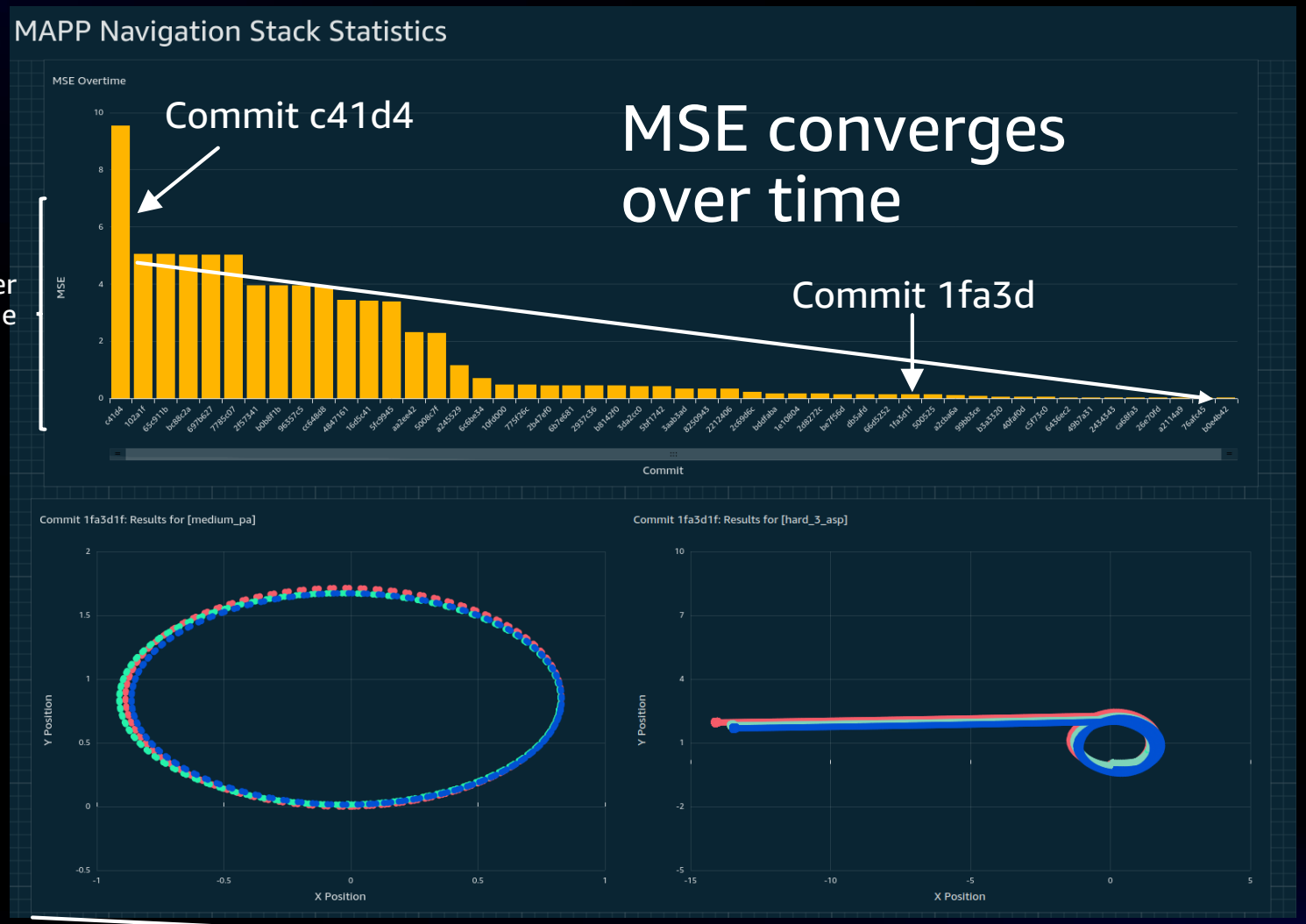
MSE over time

Test results for commit 6a503

- Part of automated CI/CD pipeline
- AWS services involved
  - QuickSight
  - AWS CodeCommit
  - AWS CodeBuild
  - Amazon ECR
  - AWS RoboMaker

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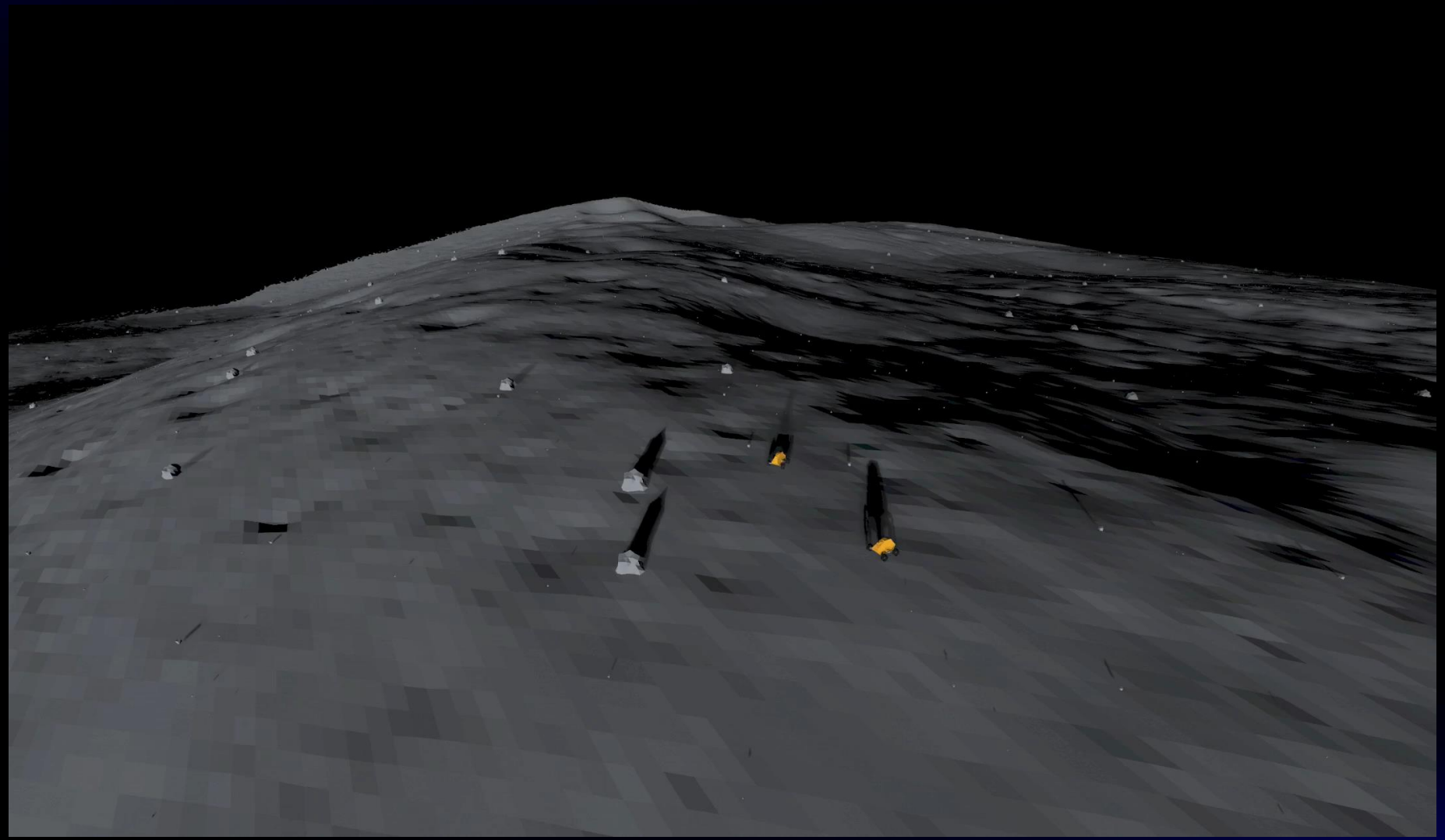
Improving navigation stack over time



Test results for commit 1fa3d

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Prospecting simulation in AWS RoboMaker



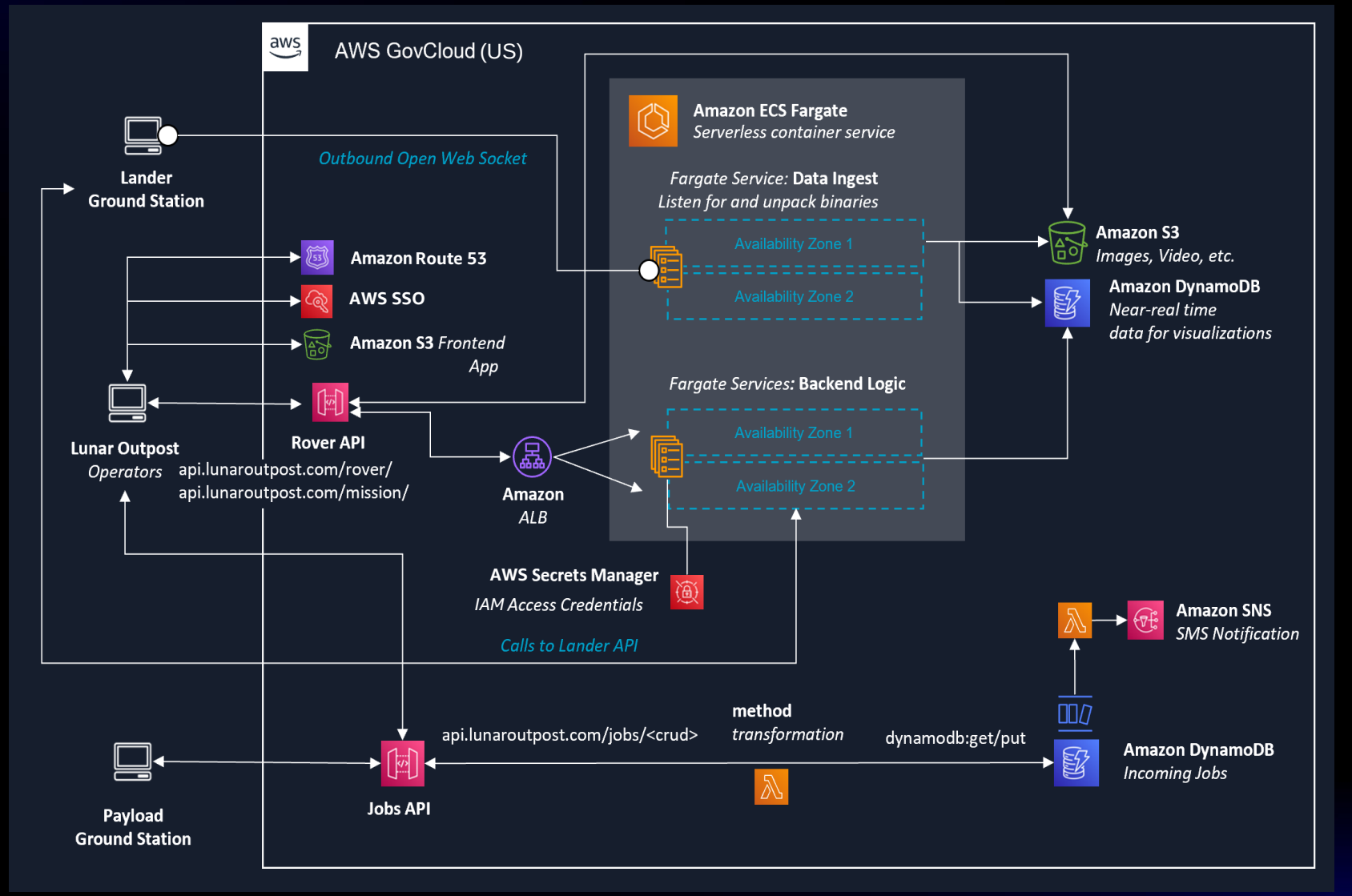
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Large swarm simulation in AWS RoboMaker



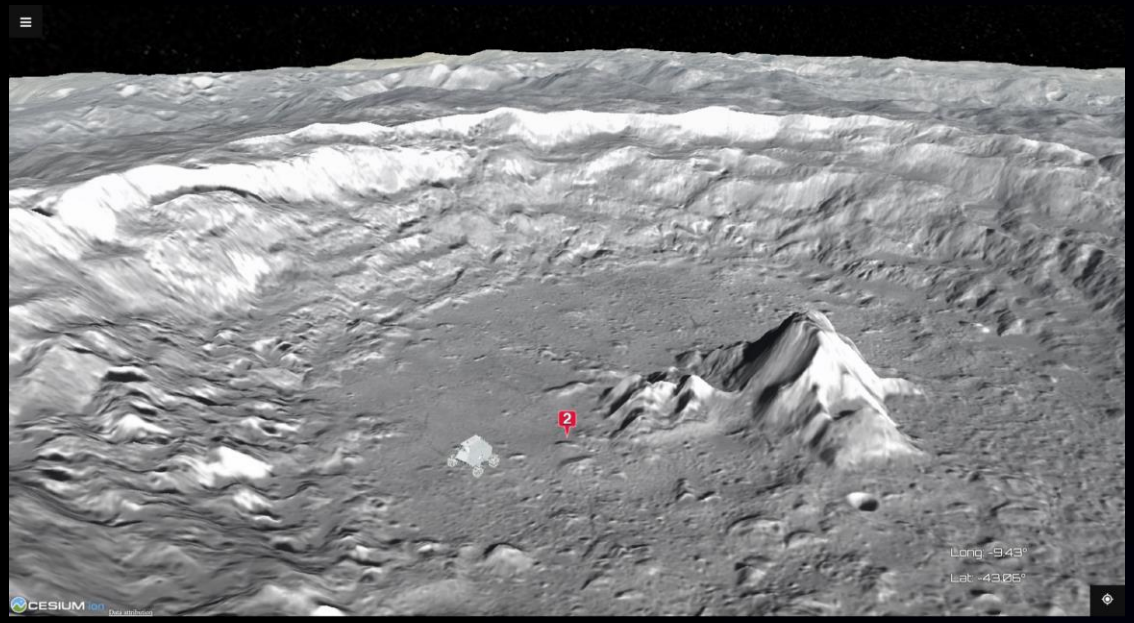
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A unified ground station tech stack



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Mission control preview





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What’s next

- Digital twin forward simulation
- Upcoming missions
- 3.5 kilograms payload space available on M1
- Simulate **payload** in a high-fidelity lunar mission simulation
- Contribute to the state-of-the-art knowledge of planetary bodies, our solar system, and our universe

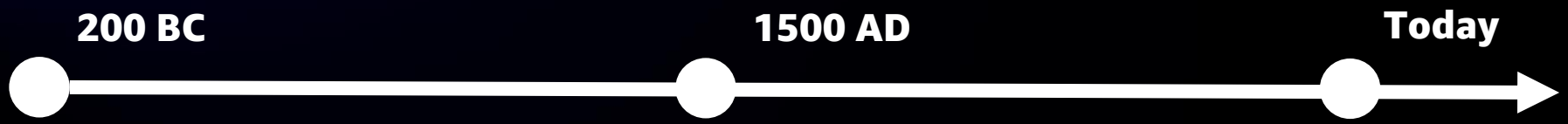
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Running robotics simulations using AWS RoboMaker

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Brief history of simulation



In **ancient Rome**, battle scenarios would be reproduced with wooden swords

Leonardo da Vinci would create scaled models to simulate his inventions before investing time in full-size prototypes

Healthcare

Agriculture

Automotive

Aviation

. . . and more

Result

Faster iteration and lower costs of mistakes accelerated learning and innovation

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Simulation benefits in robotics

Cost

- Every developer can have access to their own virtual robot for development
- Reduce the cost of failure in development

Safety

- Test robot applications in unsafe and high-risk scenarios

Speed

- Run tests faster than real time

Test coverage

- Set parameters to run tests that cover a wide range of test scenarios

Repeatability

- Reproduce conditions that led to unexpected behaviors
- Run regression tests using custom scenarios

Fast prototyping

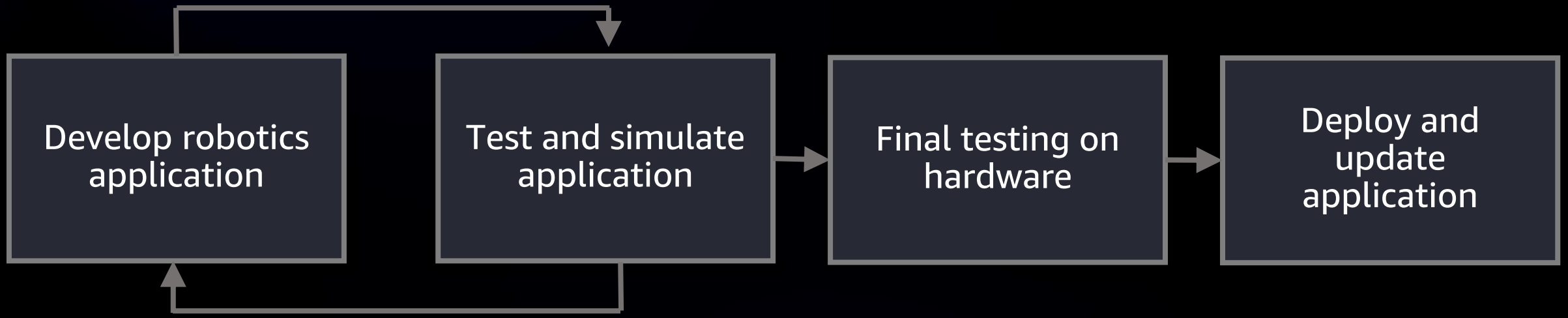
- Decouple physical development from software development

Business outcomes in robotics	Faster time to market, increased feature release velocity, and fewer software defects in production

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Robot software development cycle



AWS RoboMaker
Simulation service

AWS IoT Greengrass

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AWS RoboMaker: Managed simulation service



Run high-fidelity simulations with an API

Bring applications and simulation engines as containers

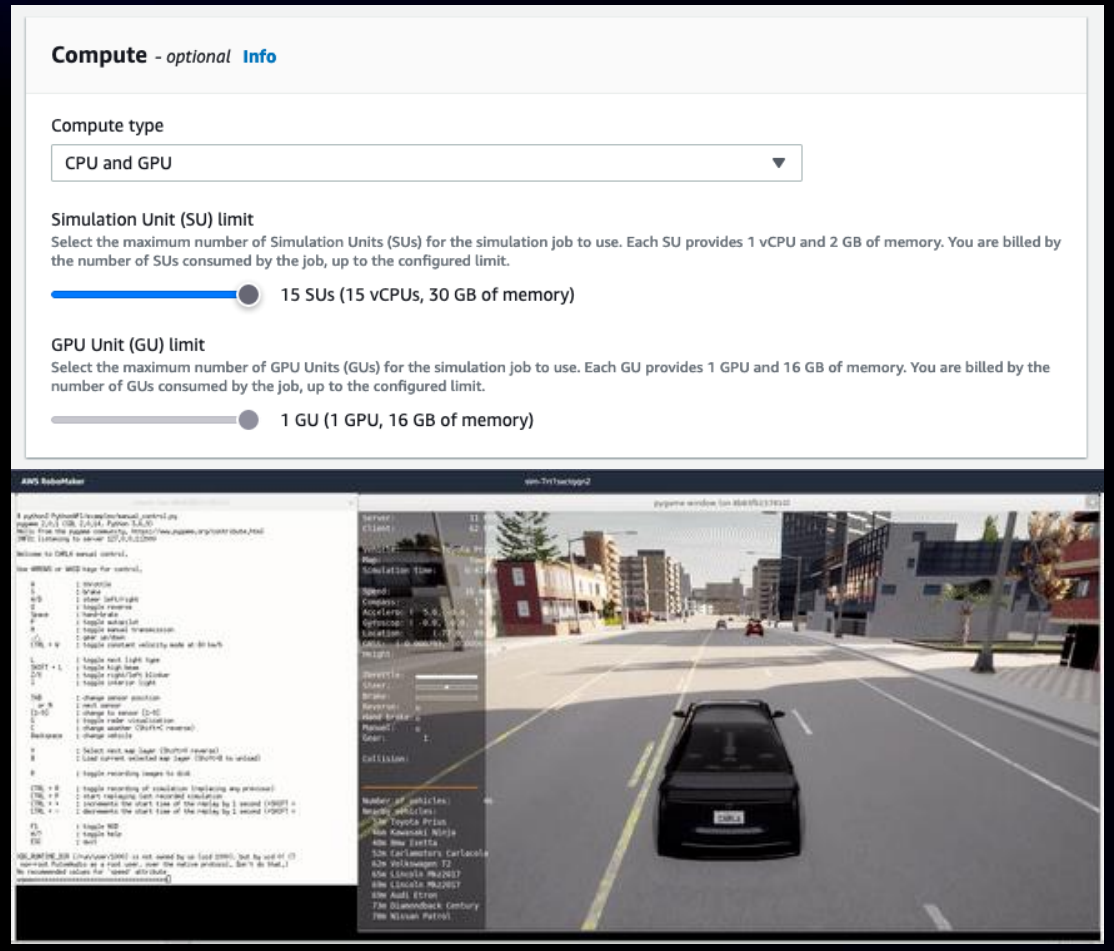
Interact with running GUI applications over a browser

Define custom Amazon S3 upload locations for data and log files

Procedurally generate 3D home worlds with different floor layouts and furniture configurations

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New features for high-fidelity simulations



GPU-based compute
High-fidelity simulations, vision processing, and machine learning

Choice of simulator
Use any simulator to run simulations in containers stored in Amazon ECR

Flexibility of robot software
Run robot applications with any ROS distribution or bring custom robot applications

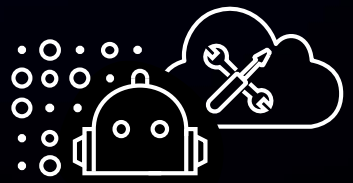
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Why AWS RoboMaker?



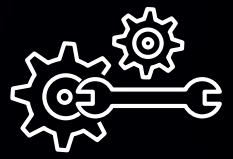
Cloud scale

Concurrent simulations at cloud scale via a single API call



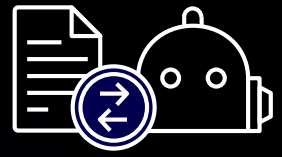
Reliable

Enterprise-grade availability with built-in health checks to ensure simulations run smoothly and reliably



Bring-your-own configuration

Bring your own simulation containers and use the engine of your choice, on CPU- or GPU-based compute



AWS service integrations

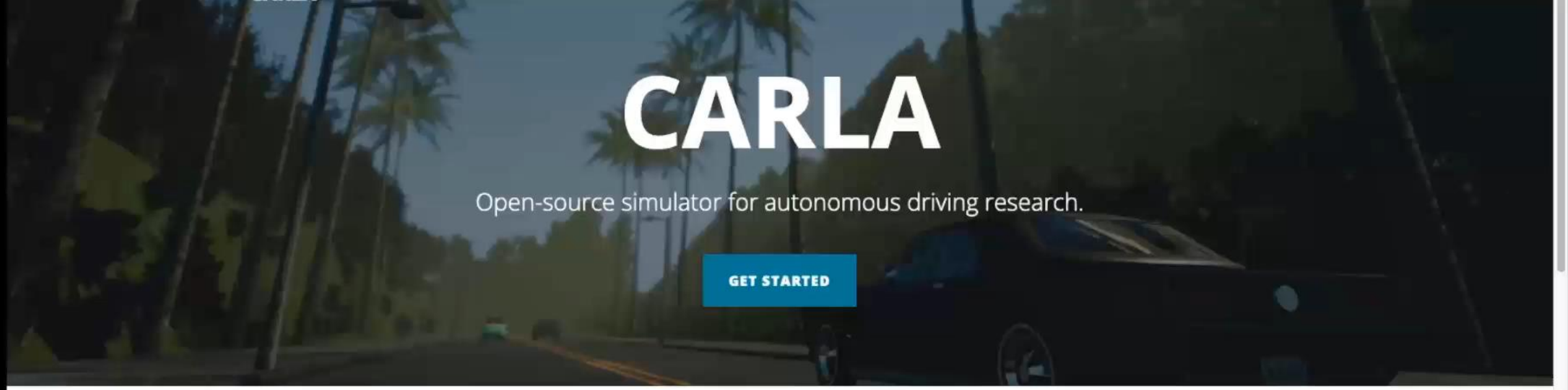
Suite of AWS services for building complete solutions



Cost-effective

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

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CARLA

Open-source simulator for autonomous driving research.

GET STARTED

Introduction

CARLA has been developed from the ground up to support development, training, and validation of autonomous driving systems. In addition to open-source code and protocols, CARLA provides open digital assets (urban layouts, buildings, vehicles) that were created for this purpose and can be used freely. The simulation platform supports flexible specification of sensor suites, environmental conditions, full control of all static and dynamic actors, maps generation and much more.

Video



Latest News

CARLA 0.9.12 Release
Posted on August 02, 2021

CARLA 0.9.11 Release
Posted on December 22, 2020

CARLA 0.9.10 release
Posted on September 25, 2020

CARLA Talks 2020
Posted on June 09, 2020

CARLA 0.9.9 release
Posted on April 22, 2020

View All Posts →

Get In Touch

AWS RoboMaker CLI and SDKs

LAUNCHING A SIMULATION IN AWS ROBOMAKER

```
aws robomaker create-simulation-job
--max-job-duration-in-seconds <value>
--iam-role <value>
--robot-applications <value>
--simulation-applications <value>
--compute <value>

[--client-request-token <value>]
[--output-location <value>]
[--logging-config <value>]
[--failure-behavior <value>]
[--data-sources <value>]
[--tags <value>]
[--vpc-config <value>]
[--cli-input-json <value>]
[--generate-cli-skeleton <value>]
```

```
import boto3
client = boto3.client('robomaker')
response = client.create_simulation_job(params)
```

CLI reference: https://docs.aws.amazon.com/cli/latest/reference/robomaker/create-simulation-job.html
SDK reference: https://boto3.amazonaws.com/v1/documentation/api/latest/reference/services/robomaker.html

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Using the batch simulation API

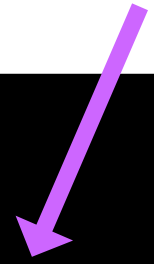
LAUNCHING A SIMULATION IN AWS ROBOMAKER

```
aws robomaker start-simulation-job-batch
--create-simulation-job-requests <value>

[--tags <value>]
[--client-request-token <value>]
[--batch-policy <value>]
[--cli-input-json <value>]
[--generate-cli-skeleton <value>]
```

```
aws robomaker start-simulation-job-batch
--cli-input-json file://batchSimulationLaunch.json
```

```
import boto3
client = boto3.client('robomaker')
response = client.start_simulation_job_batch(params)
```



```
{
   "batchPolicy": {
      "timeoutInSeconds": 800,
      "maxConcurrency": 2
   },
   "createSimulationJobRequests":
     [ <CreateSimulationJobRequestParameters> ],
   "tags": {
     “commit” : "daceddc442c7",
     “type” : ”CI_Tests”
   }
}
```

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What is a simulation job batch?
A simulation job batch is a collection of simulation job requests. You can create a new simulation job batch using the AWS RoboMaker API, or clone an existing batch by selecting "Clone" under the actions dropdown. Learn more

Simulation job batches (3) Info

Batch actions

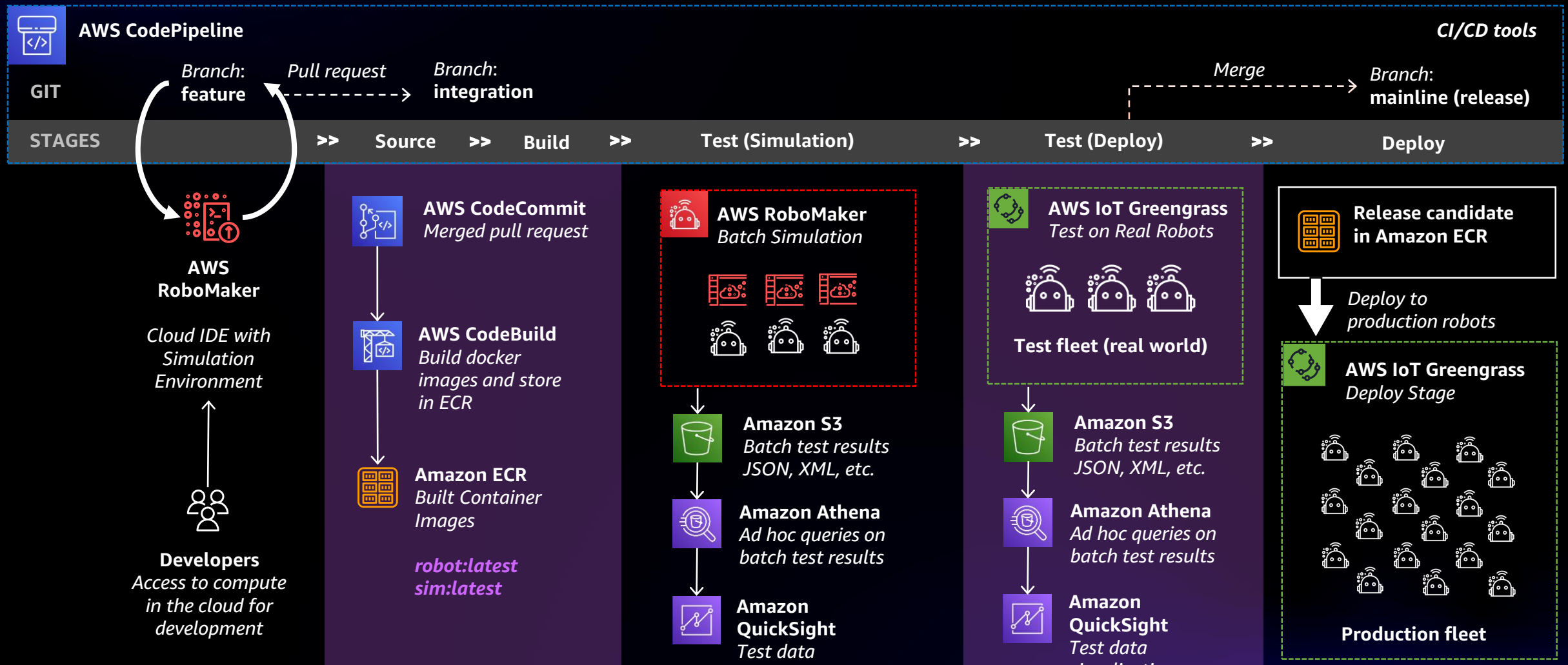
Find simulation job batches

1

ID	Status	Created requests	Failed reque...	Created time	Elapsed tir
sim-batch-xb2hrxqm76s2	Completed	3/3	0	October 27, 2021 12:17:14 PM	00:12:13
sim-batch-rzzdgkkfv9vd	Completed	3/3	0	October 27, 2021 11:56:29 AM	00:13:03
sim-batch-w0j842np6r0g	Completed	0/3	3	October 27, 2021 11:53:29 AM	00:00:08

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Automated testing with simulation and CI/CD



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Recap

Simulation enables faster development iteration, lowers costs of mistakes, and accelerates learning and innovation

Robotics companies use simulation to speed up time to market, increase feature release velocity, and reduce software defects in production

Easily run high-fidelity simulations in large batches using cloud-based compute with AWS RoboMaker simulation APIs

Automate simulation-based regression testing in CI/CD workflows using AWS integrations

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Learn more

AWS Robotics

AWS Robotics Blog
https://aws.amazon.com/blogs/robotics/

AWS RoboMaker
https://aws.amazon.com/robomaker

AWS IoT Greengrass
https://aws.amazon.com/greengrass/

Lunar Outpost

Learn more about our upcoming missions
https://lunaroutpost.com

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https://bit.ly/3mCXGAs

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