IEEE-CNSV
Consultants' Network of Silicon Valley

IEEE Consultants' Network of Silicon Valley – October 2020

🤖 Robotics Simulation using the Cloud ☁️

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aws

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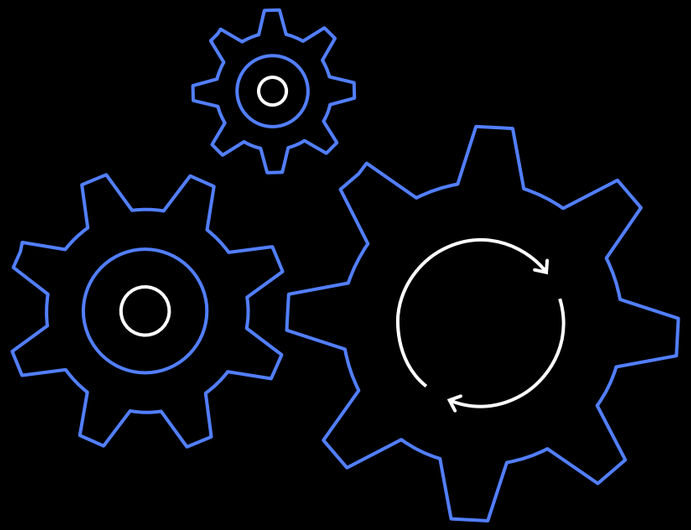
Robotics use is accelerating in key industries



Robotics is undergoing fundamental change in collaboration, autonomous mobility, and increasing intelligence

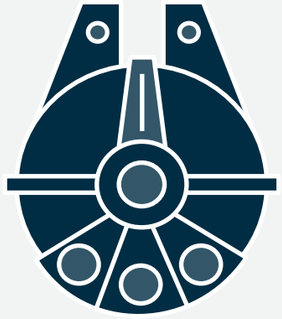
By 2023, it's estimated that mobile autonomous robots will emerge as the standard for logistic and fulfillment processes

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

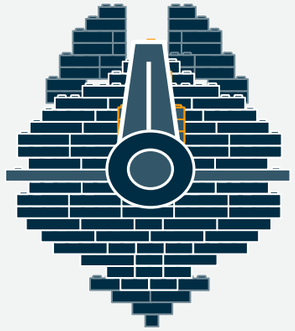
Source: IDTechEx

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

Agenda



vs

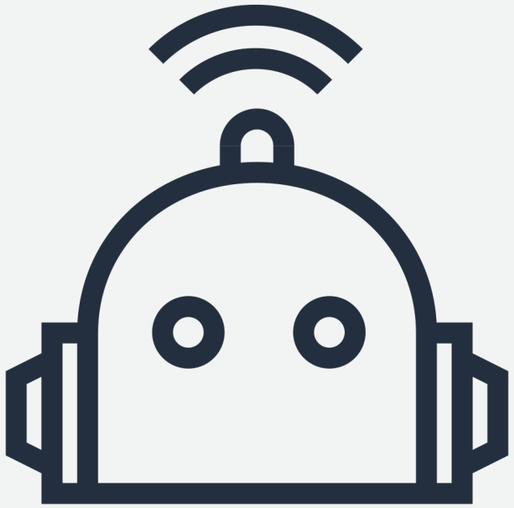


Traditional Robot Application Development

vs

Rapid Robot Application Development with Simulation in the Cloud

ROS & 2



AWS RoboMaker & WorldForge

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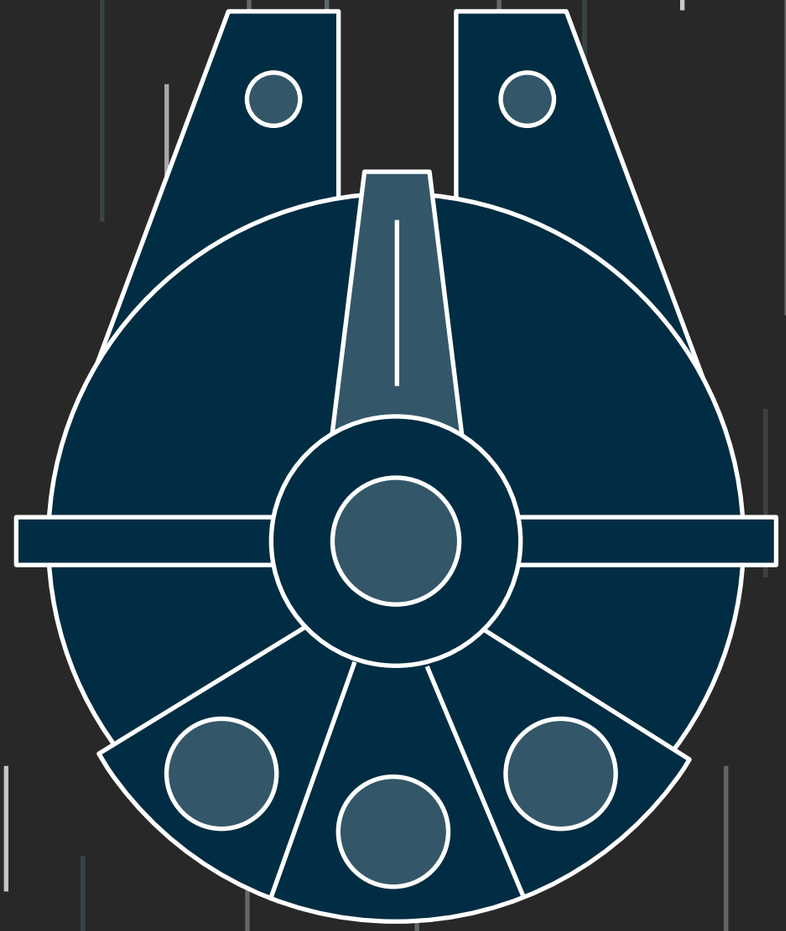
What is the Customer Need?



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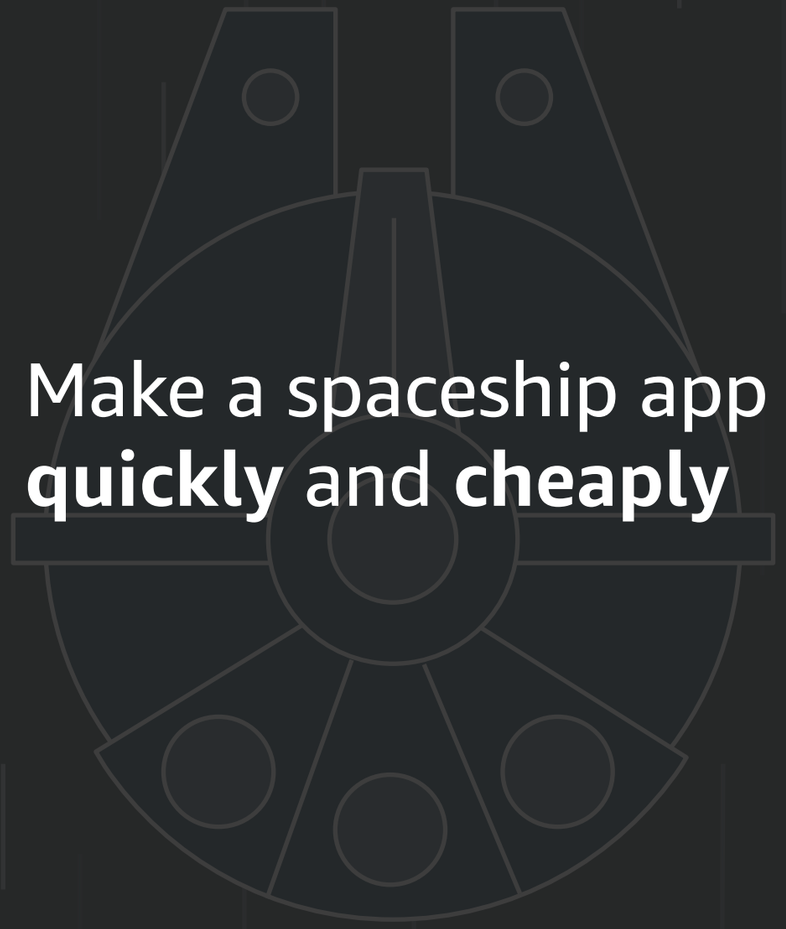
What is the Problem You Are Trying to Solve?

Make a spaceship app **quickly** and **cheaply**



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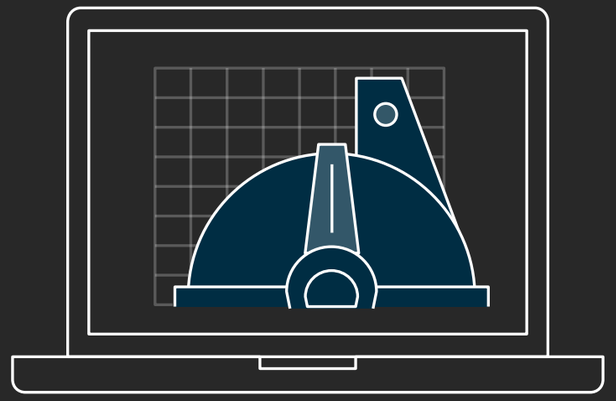
Traditional Robot Application Development



Design a prototype

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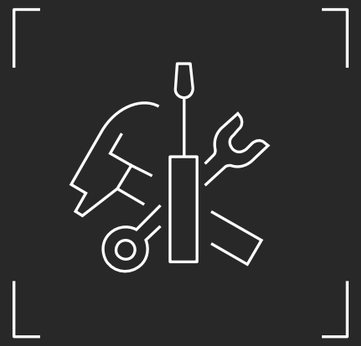
Traditional Robot Application Development



Manufacture Robot Components

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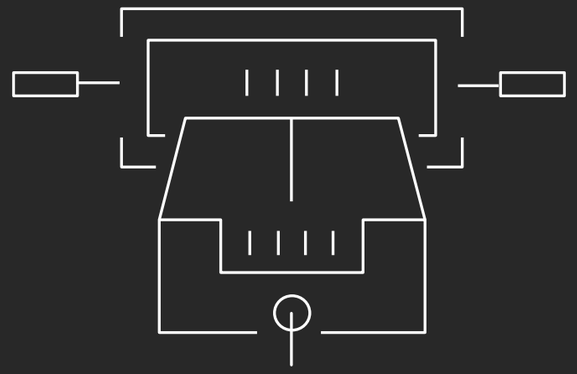
Traditional Robot Application Development



Develop Firmware

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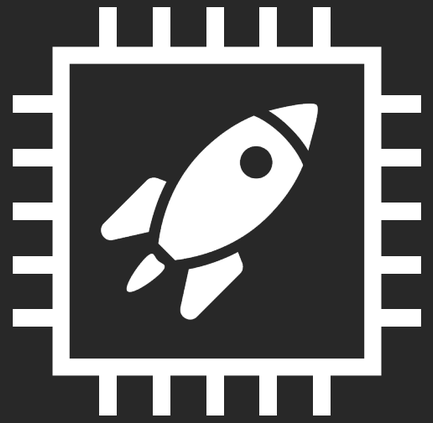
Traditional Robot Application Development



Develop Drivers

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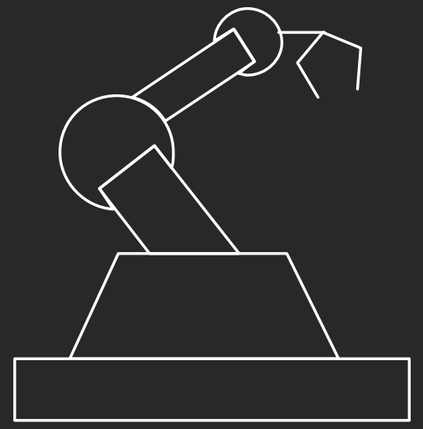
Traditional Robot Application Development



Integrate and Test

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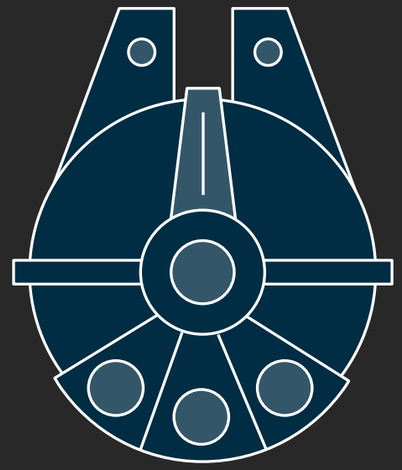
Traditional Robot Application Development



Develop Application

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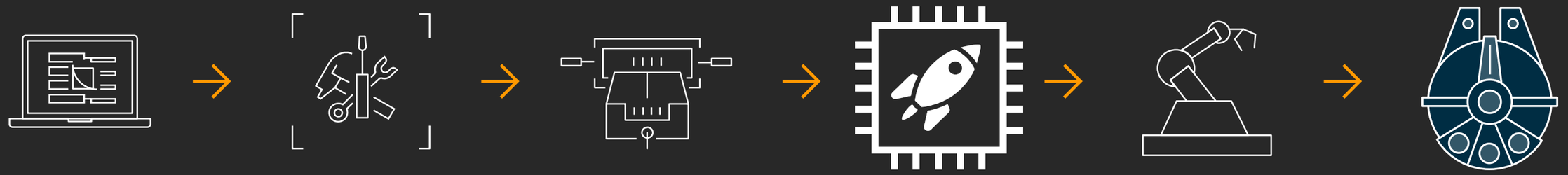
Traditional Robot Application Development



Design a prototype

Manufacture Robot Components

Develop Firmware

Develop Drivers

Integrate and Test

Develop Application

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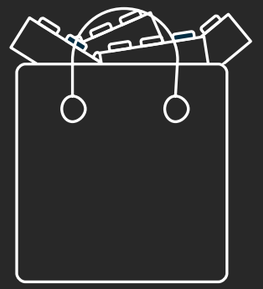
Rapid Robot Application Development

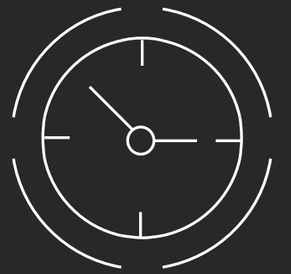


Big bag of building block software

+

Simulation Environment

+



A few hours

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Rapid Robot Application Development

A finished App

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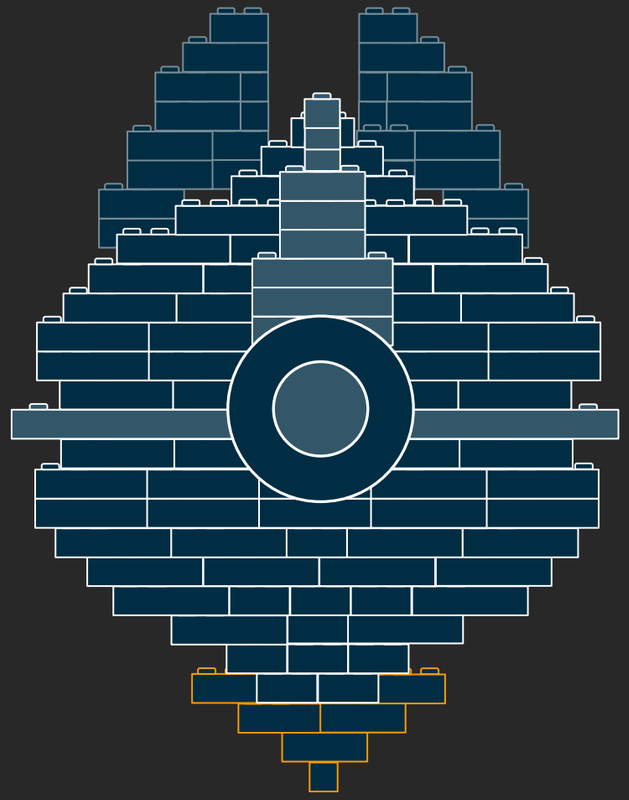
Rapid Robot Application Development



Lacks fine detail

Recognizable, but not exactly what was asked for

Easy to modify and extend

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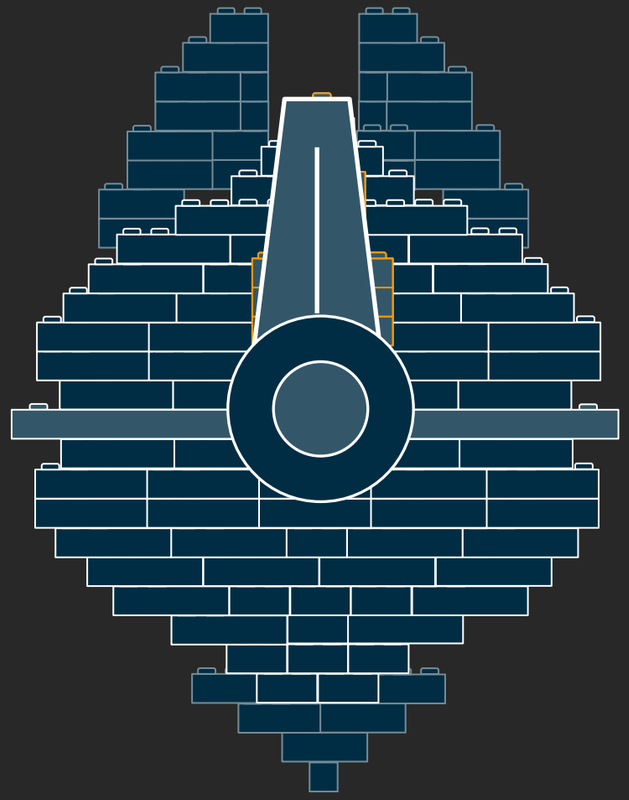
Optimization



Take a group of Lego bricks…
…and form a new custom brick
A more specialized common component

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Traditional	Rapid Development
Full custom design	Building bricks assembly
Months of work	Hours of work
Custom components may be fragile and need to be debugged and integrated	Standard reliable components scale and are well understood and interoperable
Too many detailed choices	Need to adjust requirements to fit the patterns available
Long decision cycles	Constraints tend to reduce debate and speed up decisions

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Robot Operating System (ROS)
Powering the world's robots

Most widely used open source software framework for robot application prototyping, development and deployment.

- Over 1000 developers have contributed to ROS core distros and over 2800 contributors to released packages since 2008
- Over 264 Million binary debian packages downloaded in 2019

LTS May 2016
Ubuntu 16.04
2700 Released Packages

LTS May 2018
Ubuntu 18.04
2000 Released Packages

LTS May 2020
Ubuntu 20.04
1000 Released Packages

1st ROS2 LTS
Q2 2019

ROS2 Eloquent
Q4 2019

ROS2 Foxy (LTS)
Q2 2020

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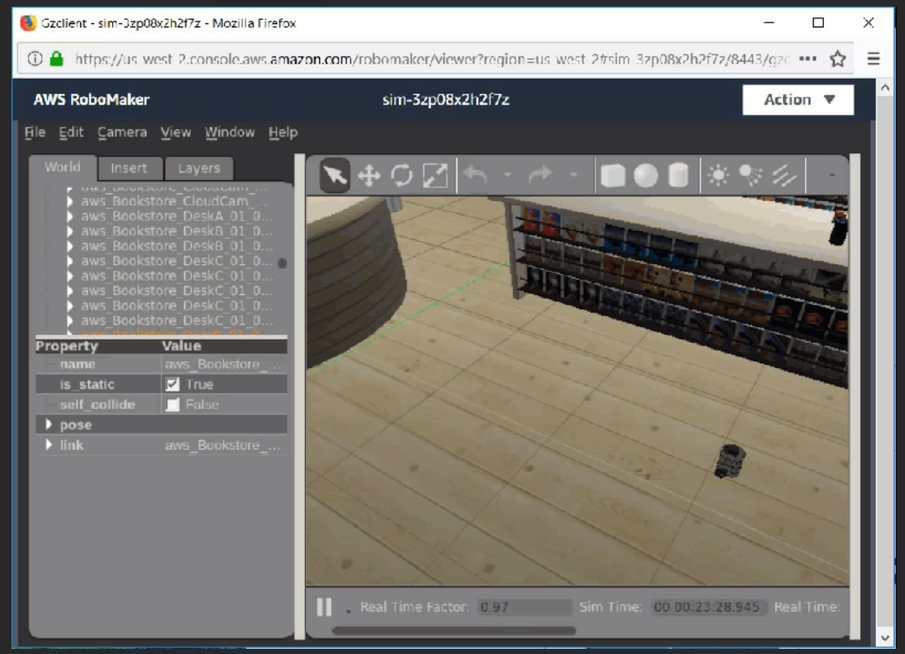
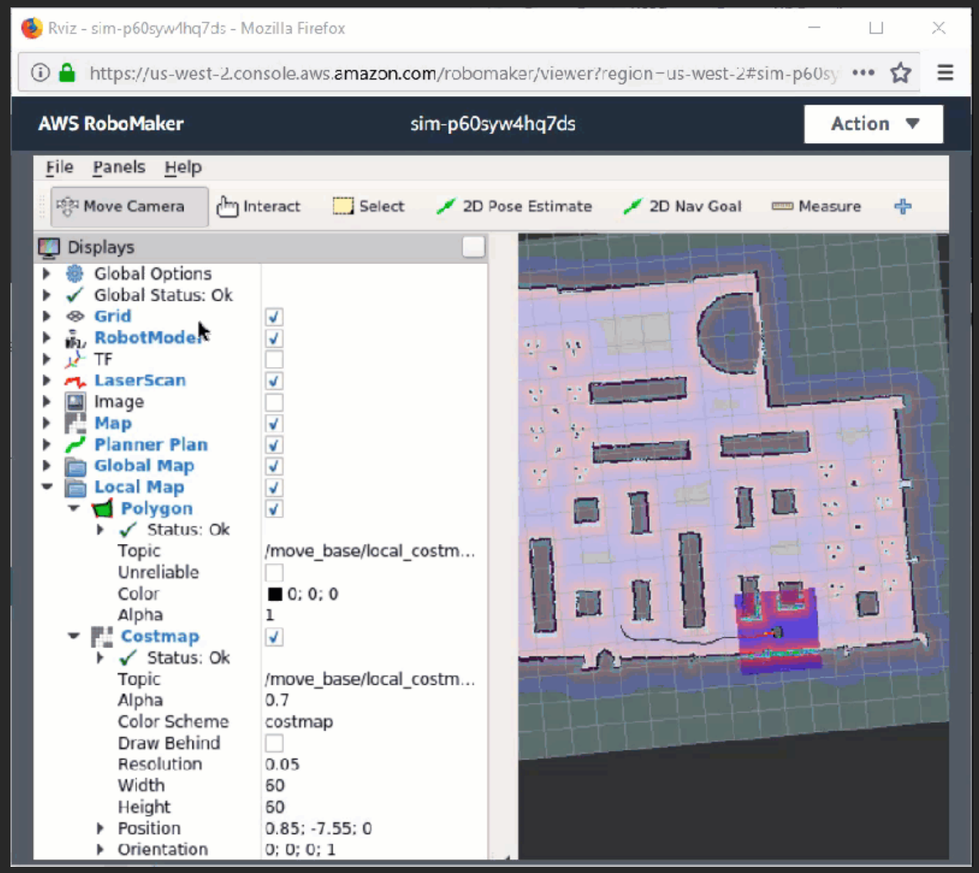
ROS: Development and Validation Tools

Gazebo



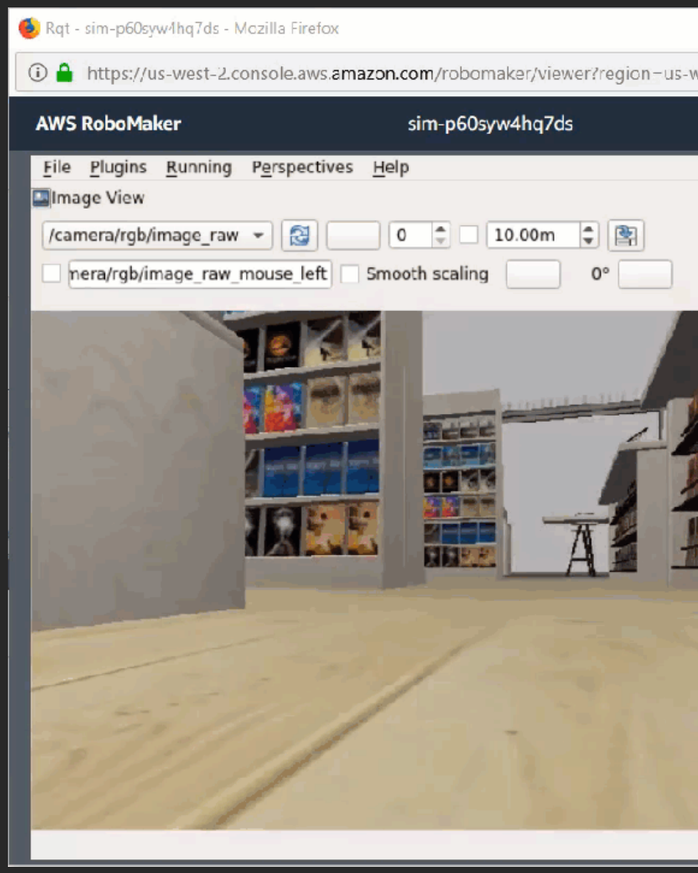
Simulation tool with robust physics engine, 3D graphics and programmatic interfaces

RViz



Visualization

rqt suite



Analysis

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Who is using ROS?

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ROS-INDUSTRIAL CONSORTIUM MEMBERSHIP

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ROS2 Architectural Changes

ROS 1

User Code	Application			
	MASTER	Node 1	Node 2	Node N
Middleware & Client Libraries	actionlib	dynamic parameters	nodelets	rospy (Python)
	roscpp (C++)			
	TCPROS/UDPROS			
OS Layer	Linux			

ROS 2

User Code	Application		
	Node 1	Node 2	Node N
Middleware & Client Libraries	rclcpp (C++)	rclpy (Python)	rcljava (Java)
	ROS Client Library (rcl)		
	ROS Abstraction Middleware (RMW)		
	Connext DDS	FastRTPS	OpenSplice DDS
OS Layer	Linux	OS X	Windows

- The core architectural change between ROS 1 and ROS 2 is the addition of the ROS Middleware (RMW) and Data Distribution Service (DDS). Which support security, reliability and determinism

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Some of AWS Robotics
Customer Obsessed Contributions to ROS 2

- Quality of Service (QoS) Features for Topics
- ROS2 Launch Sandboxing Extension
- Cross-Compilation Tools
- Nodes and example applications for AWS integration
- rosbag2 splitting, compression
- Runtime Analysis Tools Address & Thread Sanitizers

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ROS2 Technical Steering Committee

- Manage roadmap
- Contribute development efforts for core tools and libraries
- Set developer policies
- Establishes working groups to focus on important topics
  - AWS Robotics leads ROS Tooling Working Group

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Takeaways

- Open Source is a force multiplier, and continues to help grow HW and SW ecosystems: projects, communities, and commercial distributions
- Robotics Strategy must include Open Source to Win
- Robot OEMs should be first ones to adopt ROS 2, since ROS has the software, tools, and packages to support the widest and broader variety of HW compute, sensors and platforms
- Developer usage and adoption, will lead to design wins

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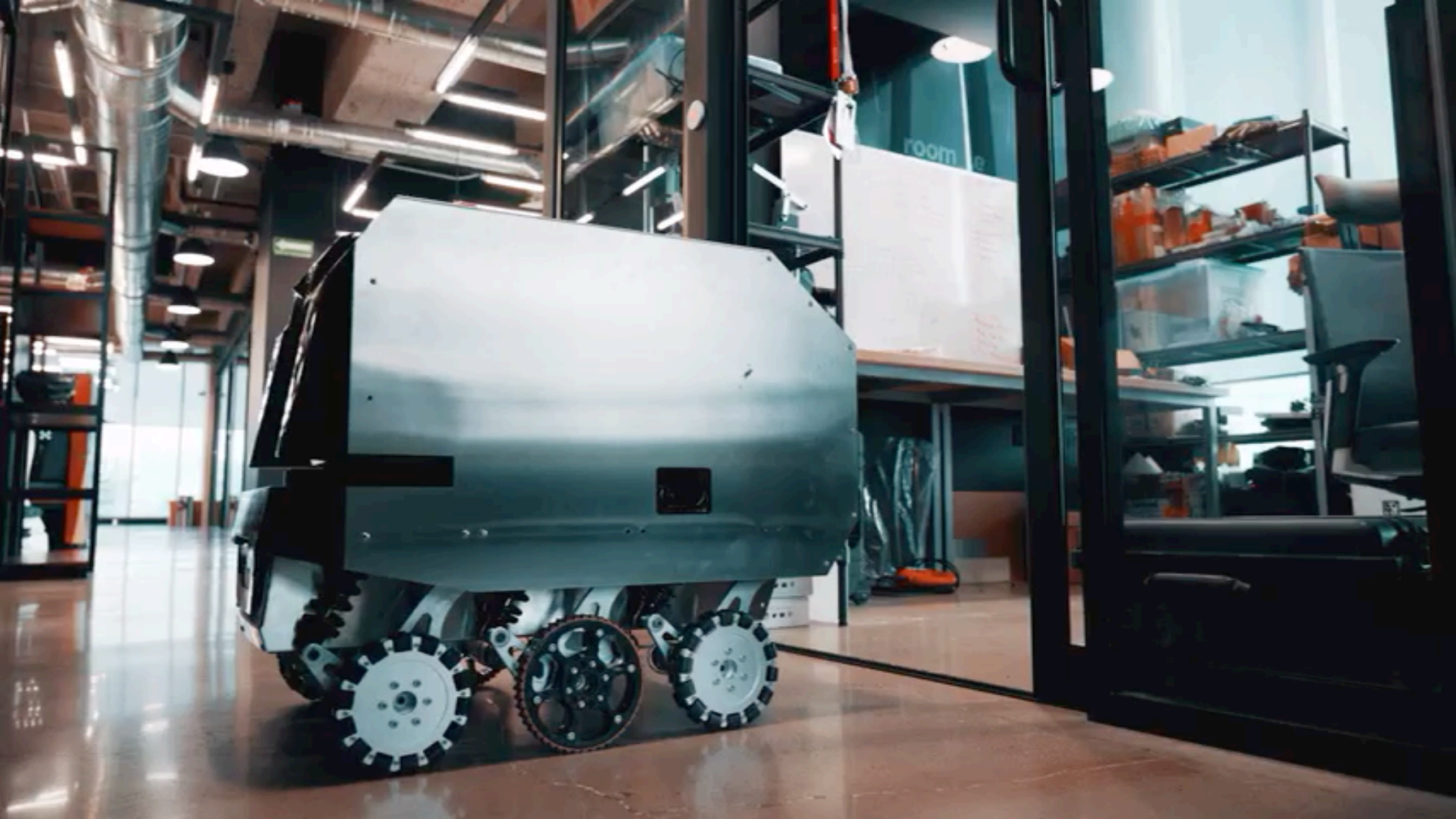
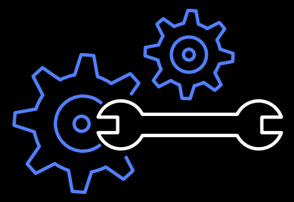
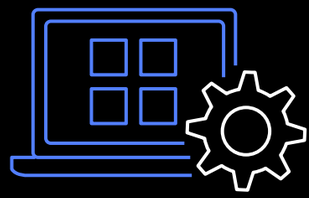

room

Robotics development and deployment challenges

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

AWS RoboMaker:

a cloud service to simulate and deploy robotics applications at cloud scale

Cloud-based simulation

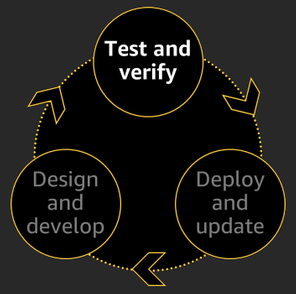
Test and verify

Design and develop

Deploy and update

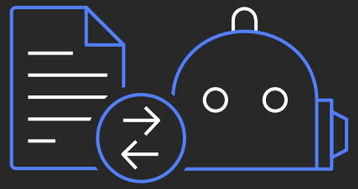
ROS & AWS integrations

Fleet management



Test and verify:
simulations at cloud scale

Simulate your environment



Test alternative scenarios

Drive optimization

Use simulations to replicate your environment, test variations, and optimize usage of robot resources

Test and verify: cloud-based simulations

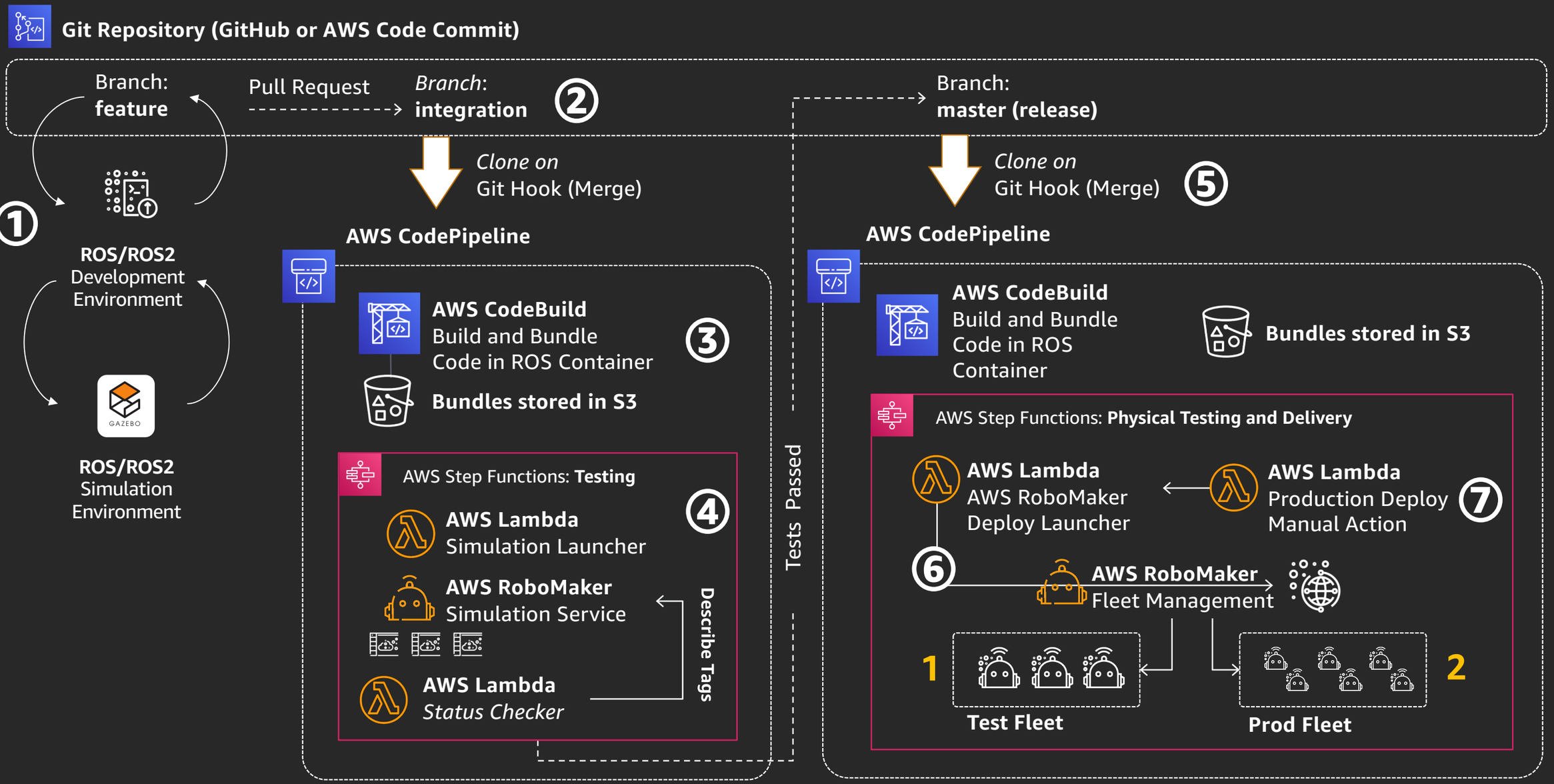
- Pre-built virtual 3D worlds provided out of box, or bring your own
- Zero infrastructure to provision, configure, or manage
- Run multiple simulations in parallel
- Auto-scale based on simulation complexity
- Pay-as-you-go simulation resource consumption

Test and verify:
regression testing with CI/CD integration

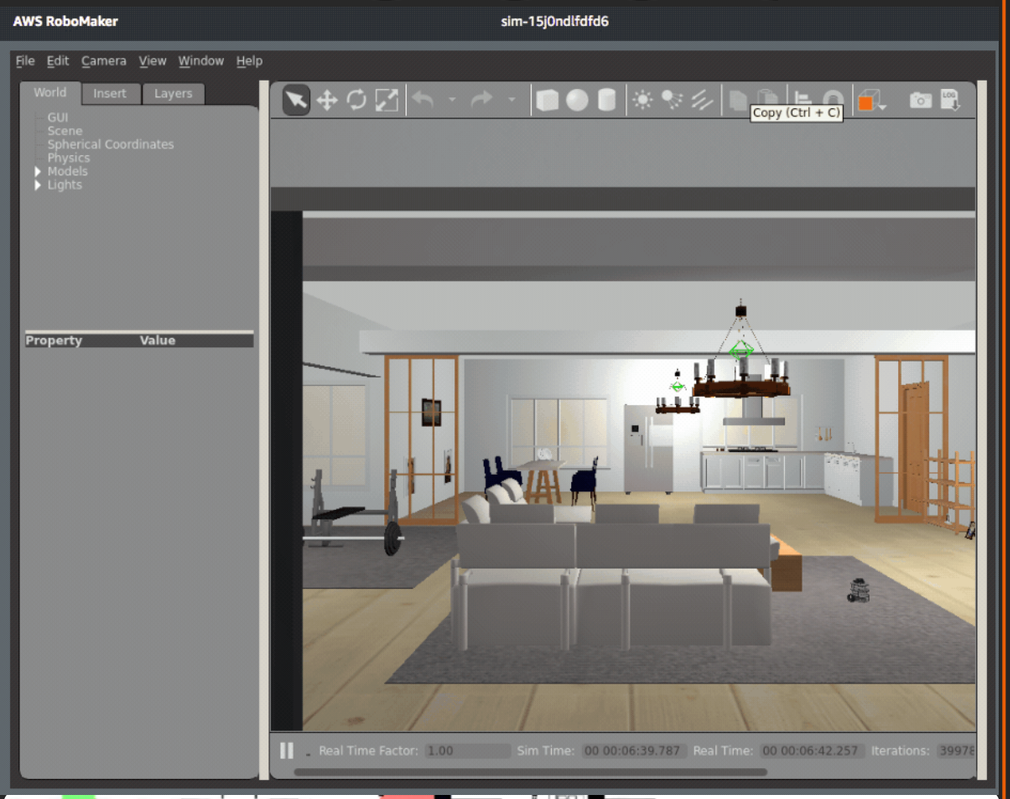
- Regression testing using either recorded rosbags or with physics-based simulators
- Large scale concurrent simulations triggered in a batch using RoboMaker simulation APIs
- Integration with CI pipeline with AWS CodePipeline and CodeBuild
- Automatically advance successful simulations every night, upon each code update, or upon each software release

AWS RoboMaker

ROS Application CI/CD Workflow
Application Architecture



iRobot®



iRobot accelerates robot regression testing

Need

Test coverage for different floor layouts and scenarios

Improve code release speed

Challenges

Costly and time consuming to test

Limited test cases and coverage

Late bug discovery in the field

Solution

iRobot built a CI/CD pipeline for large-scale and automated testing using RoboMaker's simulation service

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

Much faster testing and release cycle (1 hour versus 3 weeks for testing 70 complex localization scenarios)

How iRobot Uses AWS RoboMaker to Build, Test and Manage Millions of Robots

www.youtube.com/watch?v=LS2k3i-Id4Q

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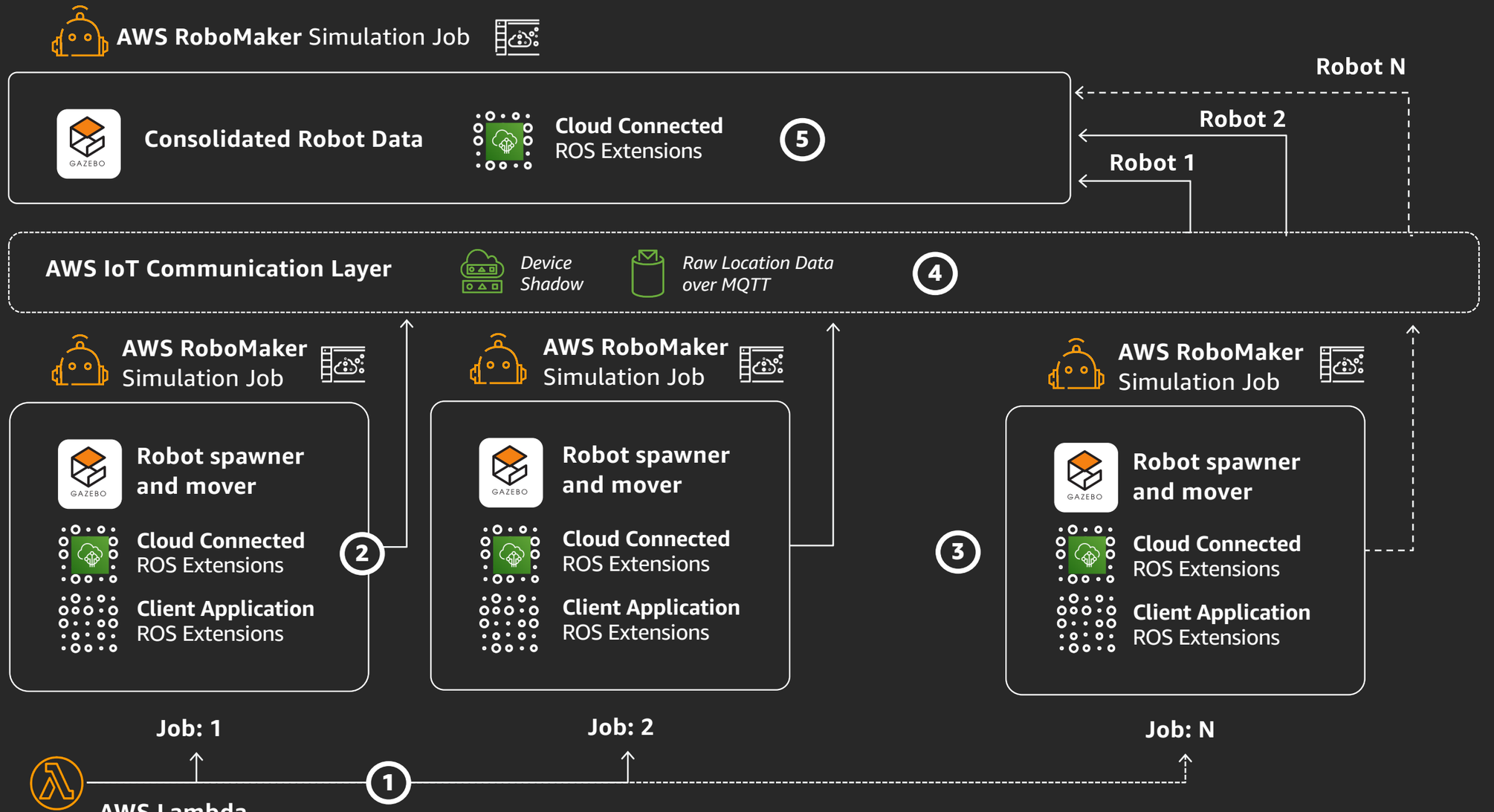
Test and verify: multi-robot simulations

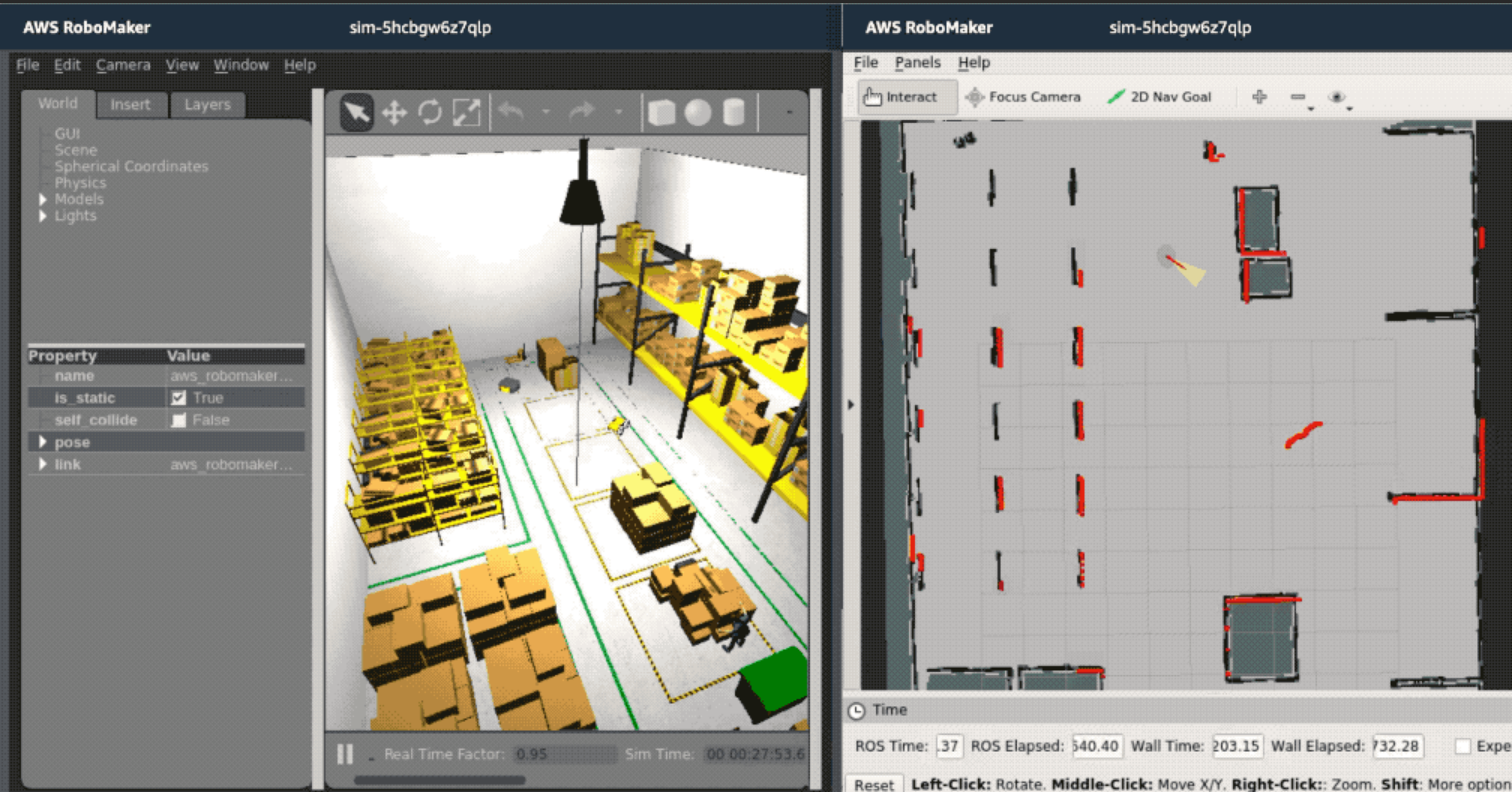
- Simulate multiple robots in a fleet
- Connect multiple simulations to a central fleet-management software to test multi-robot scenarios
- Simulate inter-robot interactions or missions across robots

AWS RoboMaker

Multiple Robots in Simulation
Application Architecture

https://github.com/aws-samples/multi-robot-fleet-sample-application



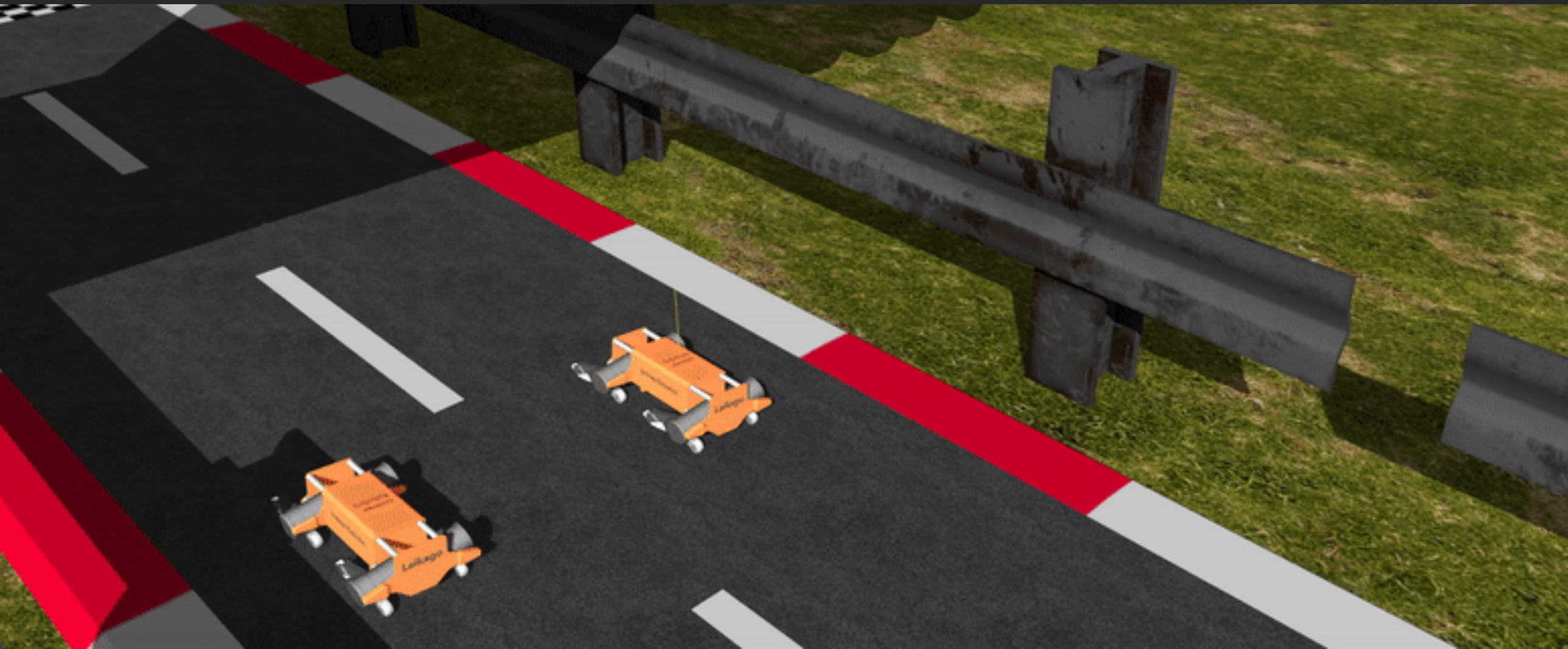

AWS RoboMaker
sim-5hcbgw6z7qlp
File Edit Camera View Window Help
World Insert Layers
GUI
Scene
Spherical Coordinates
Physics
Models
Lights
Property Value
name aws_robomaker...
is_static True
self_collide False
pose
link aws_robomaker...
Real Time Factor: 0.95
Sim Time: 00 00:27:53.6
AWS RoboMaker
sim-5hcbgw6z7qlp
File Panels Help
Interact
Focus Camera
2D Nav Goal
Time
ROS Time: .37 ROS Elapsed: 540.40 Wall Time: 203.15 Wall Elapsed: 732.28
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click:: Zoom. Shift: More option

Design and develop:
ROS and ROS packages for AWS integrations

- Support for ROS Kinetic, ROS Melodic, ROS 2 Dashing (beta)
- Native ROS packages for AWS services:
- Amazon S3 for secure, scalable storage
- Amazon CloudWatch for logging and metrics
- Amazon Rekognition for image and video recognition
- Amazon Kinesis for video streaming
- Amazon Lex and Amazon Polly for voice recognition and text-speech conversion

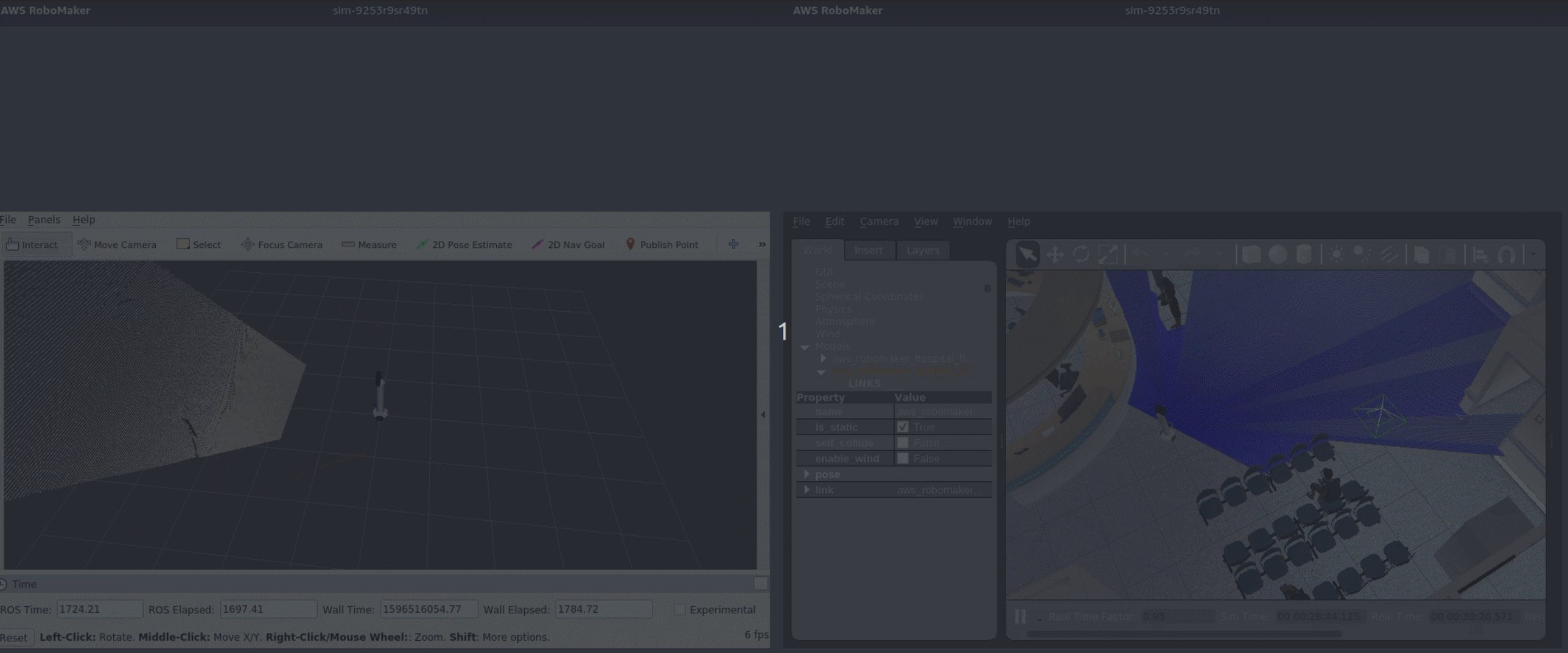
Racetrack World

https://github.com/aws-robotics/aws-robomaker-racetrack-world



Open Source Hospital World

https://aws.amazon.com/blogs/robotics/hospital-world-simulating-robot/
https://github.com/aws-robotics/aws-robomaker-hospital-world



Simulation bottleneck: world authoring

Even with good tools and excellent artists, never enough hand-crafted worlds

Need automation to create massive sets of environments for testing

AWS RoboMaker WorldForge Simplifies Creating Simulation Worlds for Robotics

https://www.youtube.com/watch?v=tD-a2WNAsSs

AWS RoboMaker WorldForge

A new AWS RoboMaker capability that automatically generates one or more residential simulation worlds within minutes

- Out-of-the box 3D assets and world templates
- Generate a world within minutes versus weeks or months
- $1.5 per generated world versus thousands of dollars
- Concurrent world generation up to hundreds of worlds
- Fully integrated with RoboMaker Simulation

AWS RoboMaker WorldForge

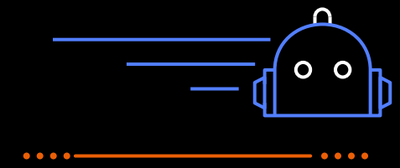
- Creating a simulation world is ~~hard~~ now much easier
- Creating a simulation world is ~~time consuming~~ now much faster
- Creating a simulation world is ~~costly~~ now much cheaper

Try AWS RoboMaker today!

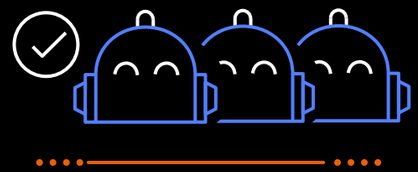
- Pre-configured ROS and ROS 2.0
- Cloud simulation service
- Regression testing via batch simulation and CI/CD pipeline
- Simulate multi-robot environments
- Cloud-based fleet management

aws.amazon.com/robomaker

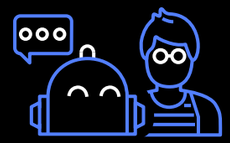
Resources



Tutorials



Developer Guide



Blog