

The Robotic Edge

The Role of the Cloud In the Future of Robotics



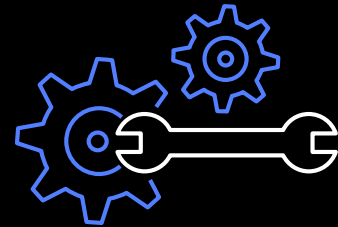
Roger S. Barga, PhD
GM, AWS Robotics



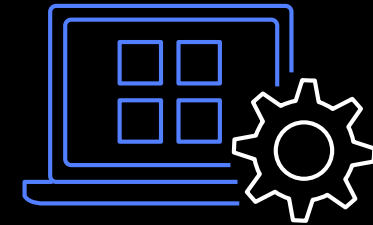
Robotics development and deployment challenges



.....
Multi-domain expertise
required to build robots



.....
Iterative development
to get it right



.....
Configuration
management is hard

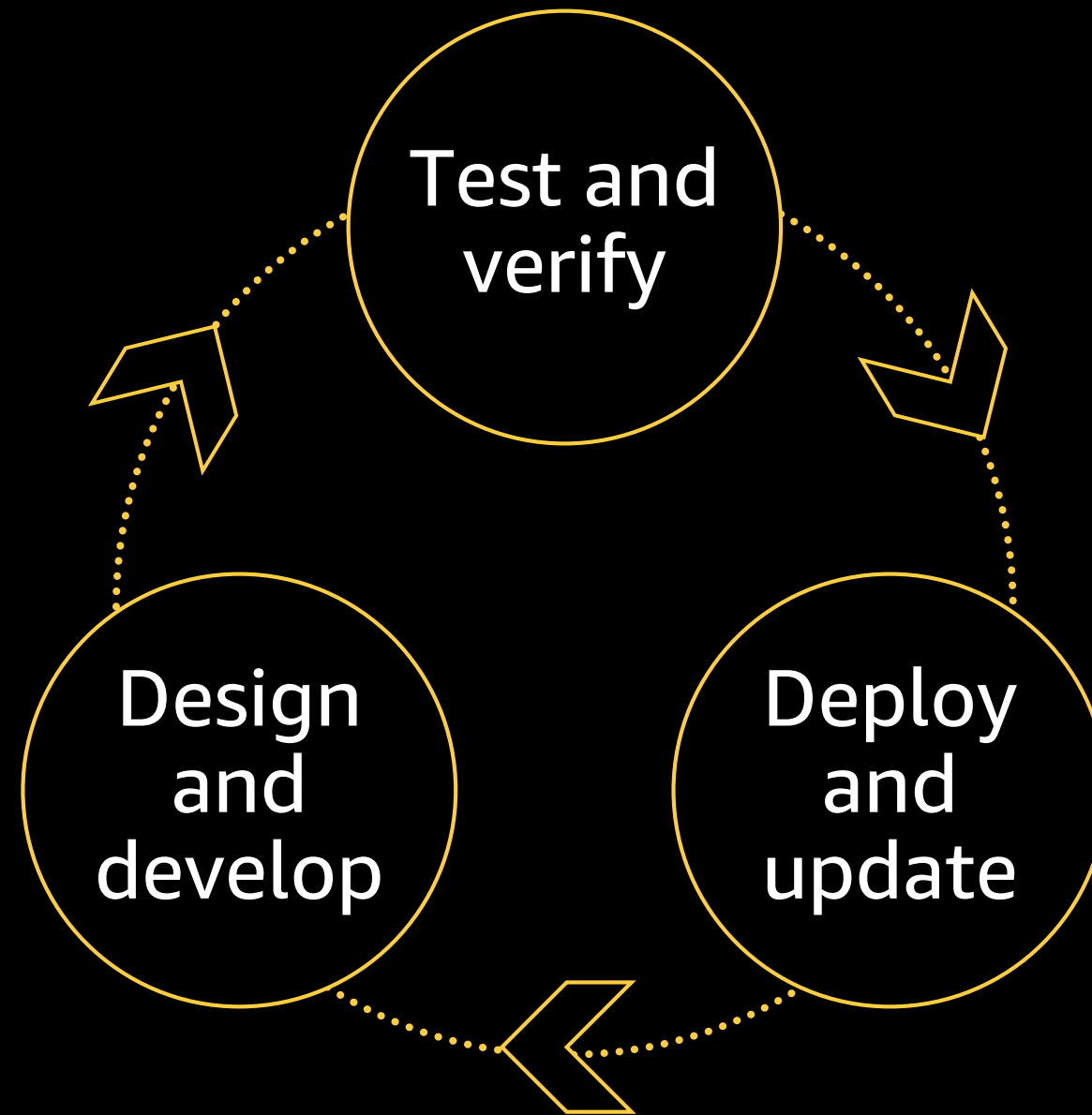


.....
Limited robot hardware
available for testing



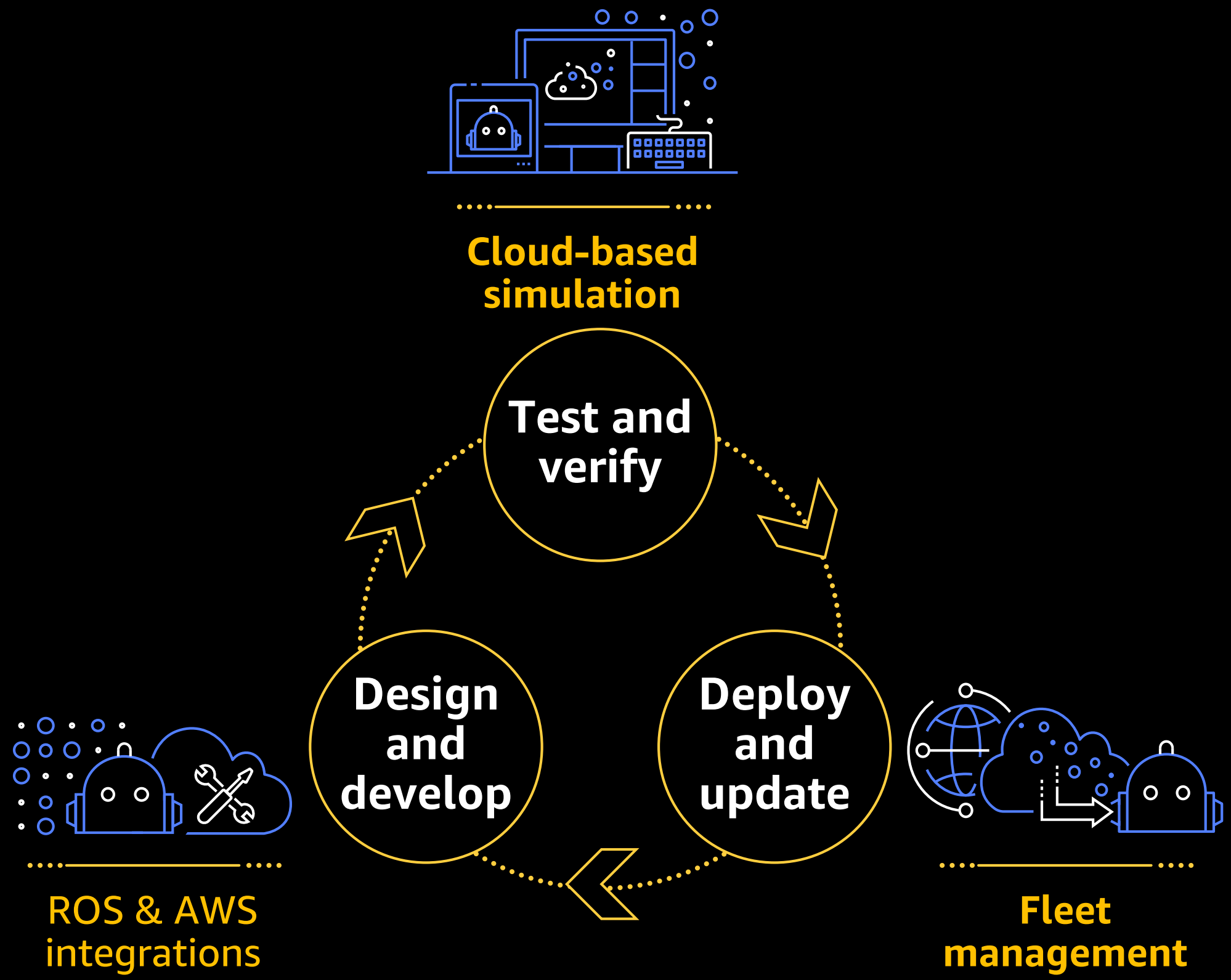
.....
Deployment and updates
need to be managed

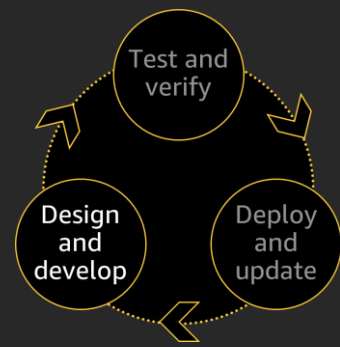
Robotics application development



AWS RoboMaker

a cloud service to build, test, deploy, and manage robotics applications at cloud scale





Design and Develop

robotics applications and functionality

ROS

GAZEBO

Agile development of robotics application requires software reuse and iterative development

ROS2

Core architectural change between ROS 1 and ROS 2:

Addition of ROS Middleware (RMW) & Data Distribution Service (DDS).

- Security
- Reliability
- Determinism

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)		
	Connex DDS	FastRTPS	OpenSplice DDS
OS Layer	Linux	OS X	Windows



AWS Robotics

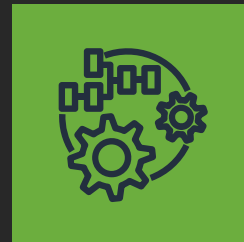
Select contributions
to ROS2



Quality of Service (QoS)
Features for Topics



ROS2 Launch
Sandboxing Extension



Cross-Compilation Tools



Nodes and example
applications for AWS
integration



rosvbag2
splitting, compression



Runtime Analysis Tools
Address & Thread
Sanitizers

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

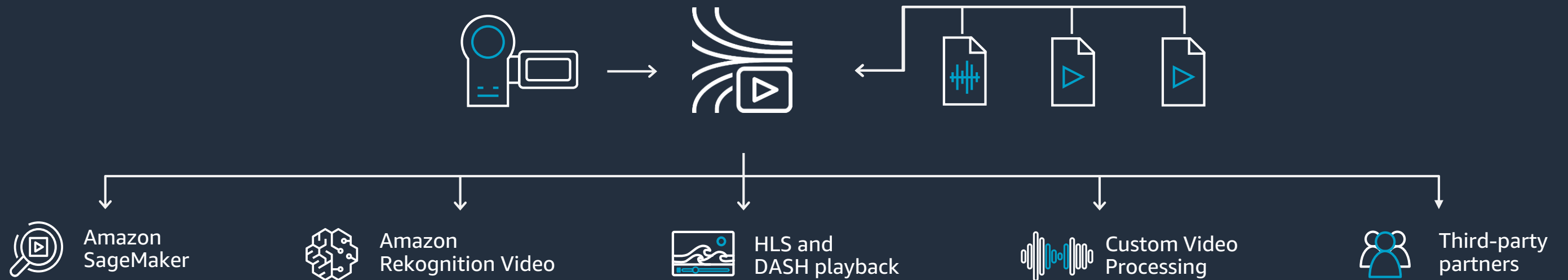
Amazon Kinesis Video Streams



Welcome to Amazon Go and the world's most advanced shopping technology. No lines, no checkout—just grab and go!

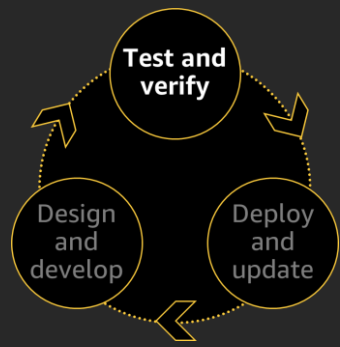


Amazon Kinesis Video Streams



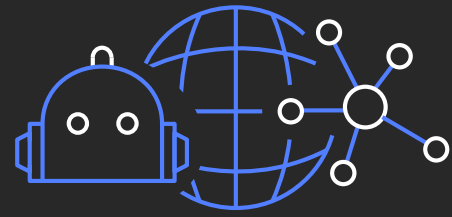
Ingests, stores, and indexes video streams from millions of cameras



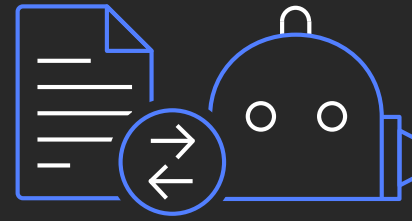


Test & Verify

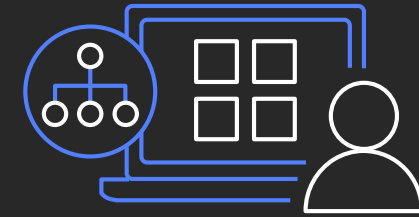
simulations at cloud scale



Simulate your environment



Test alternative scenarios



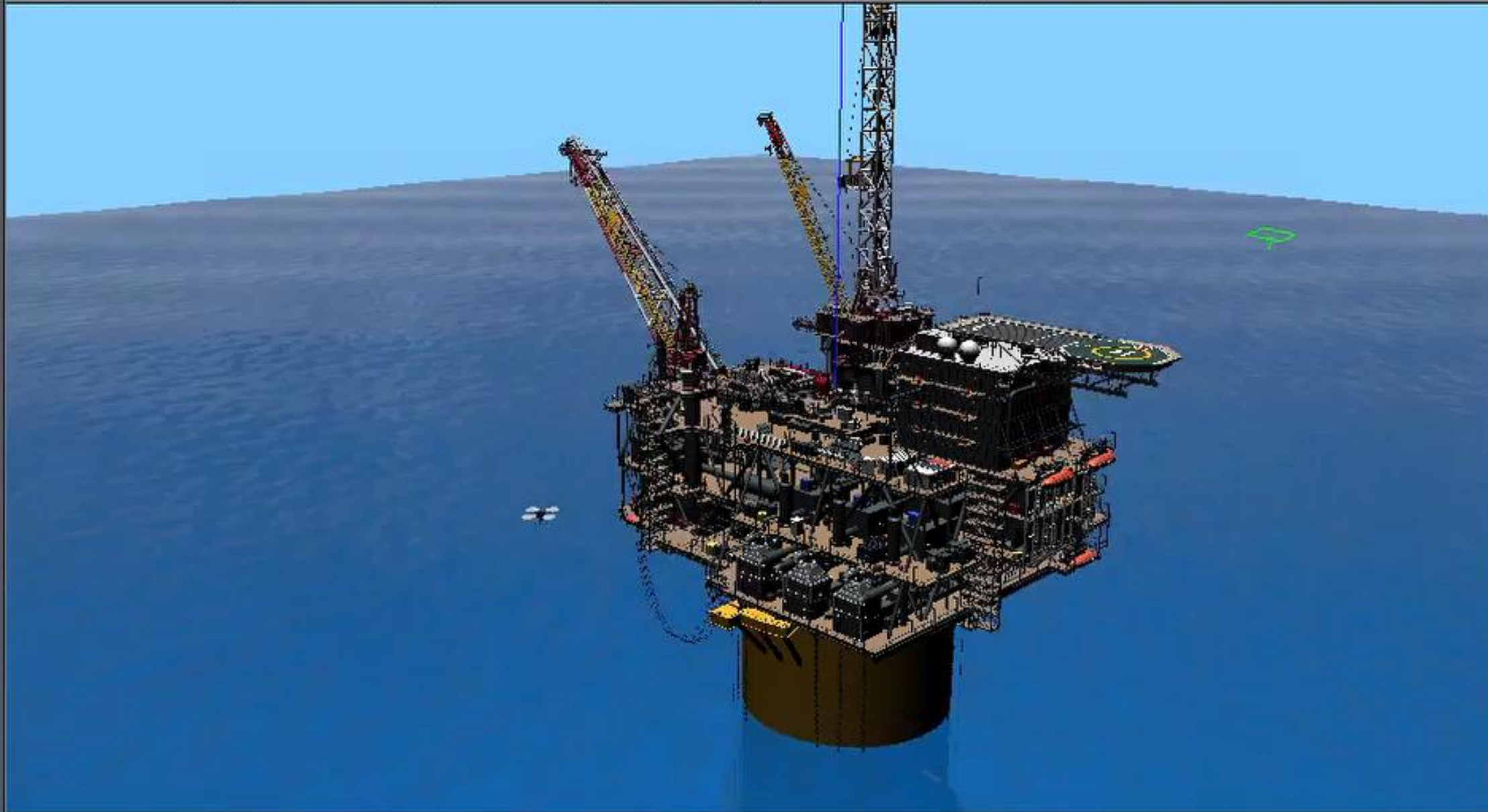
Drive optimization

Use simulation to replicate your environment, test application, and optimize usage of robot resources

Test & 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

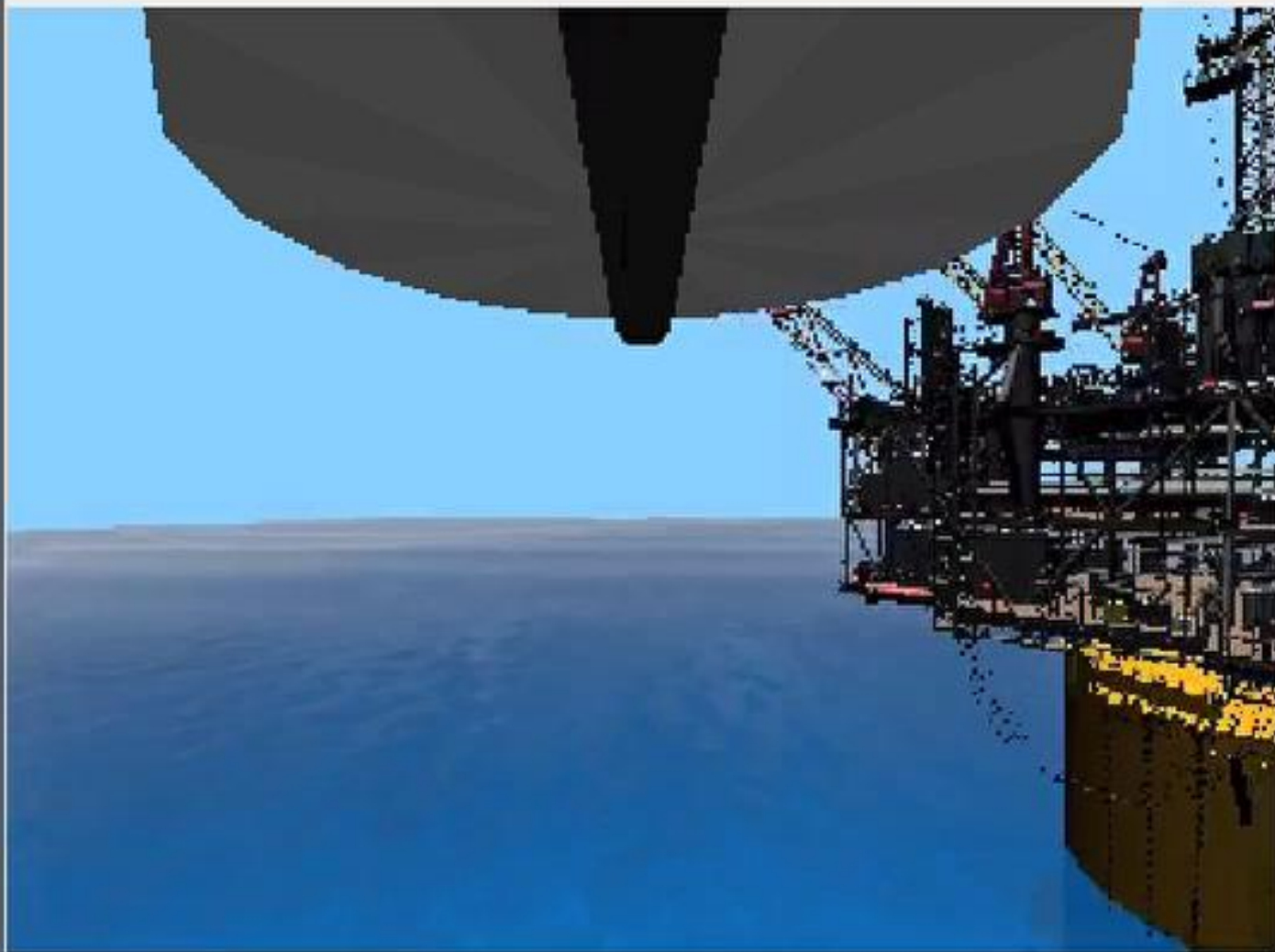


File Plugins Running Perspectives Help

Image View

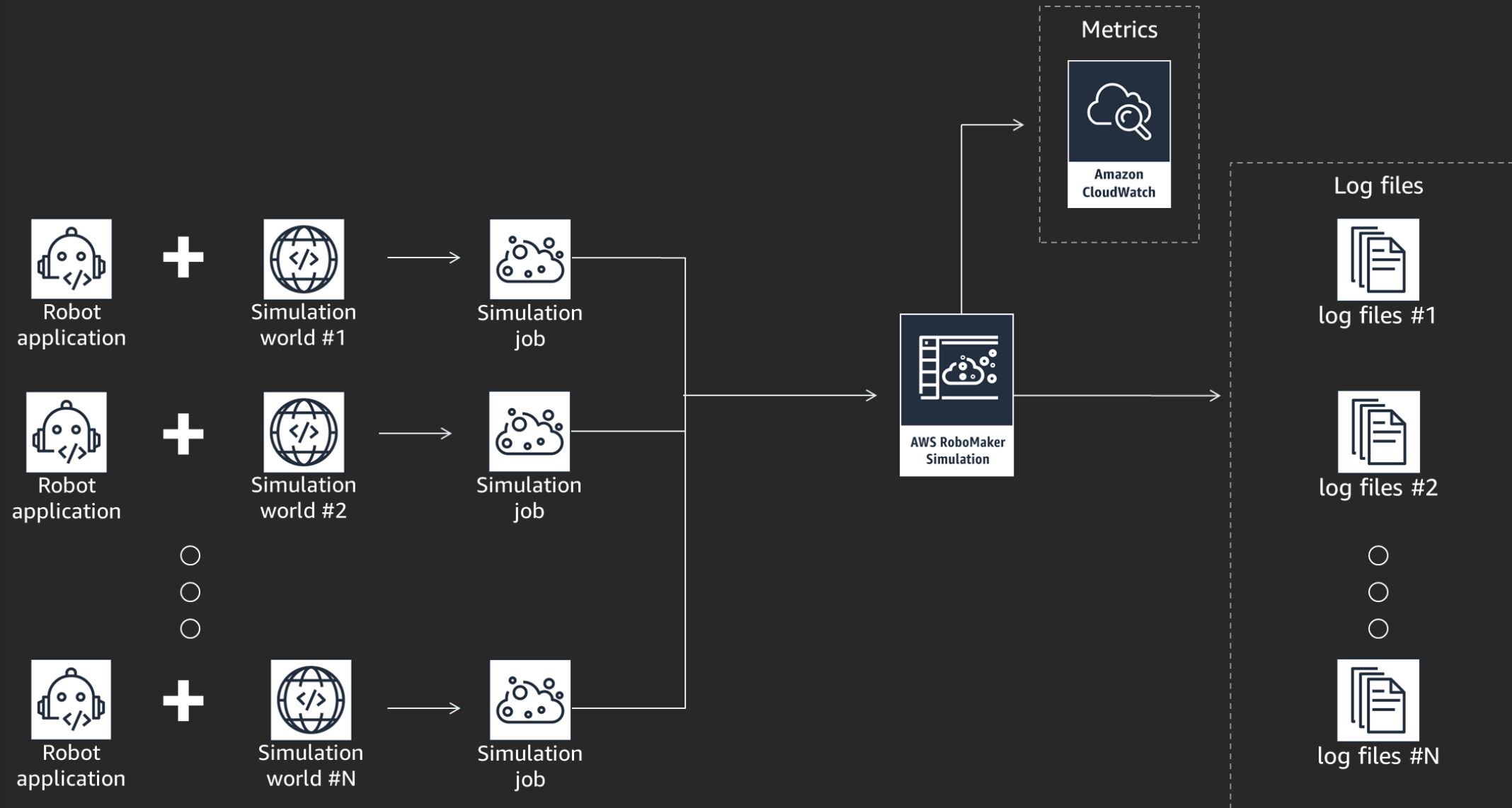
D ? - O X

Smooth scaling



Test & Verify

Able to run thousands of concurrent simulations





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)



In Production Within 3 months!

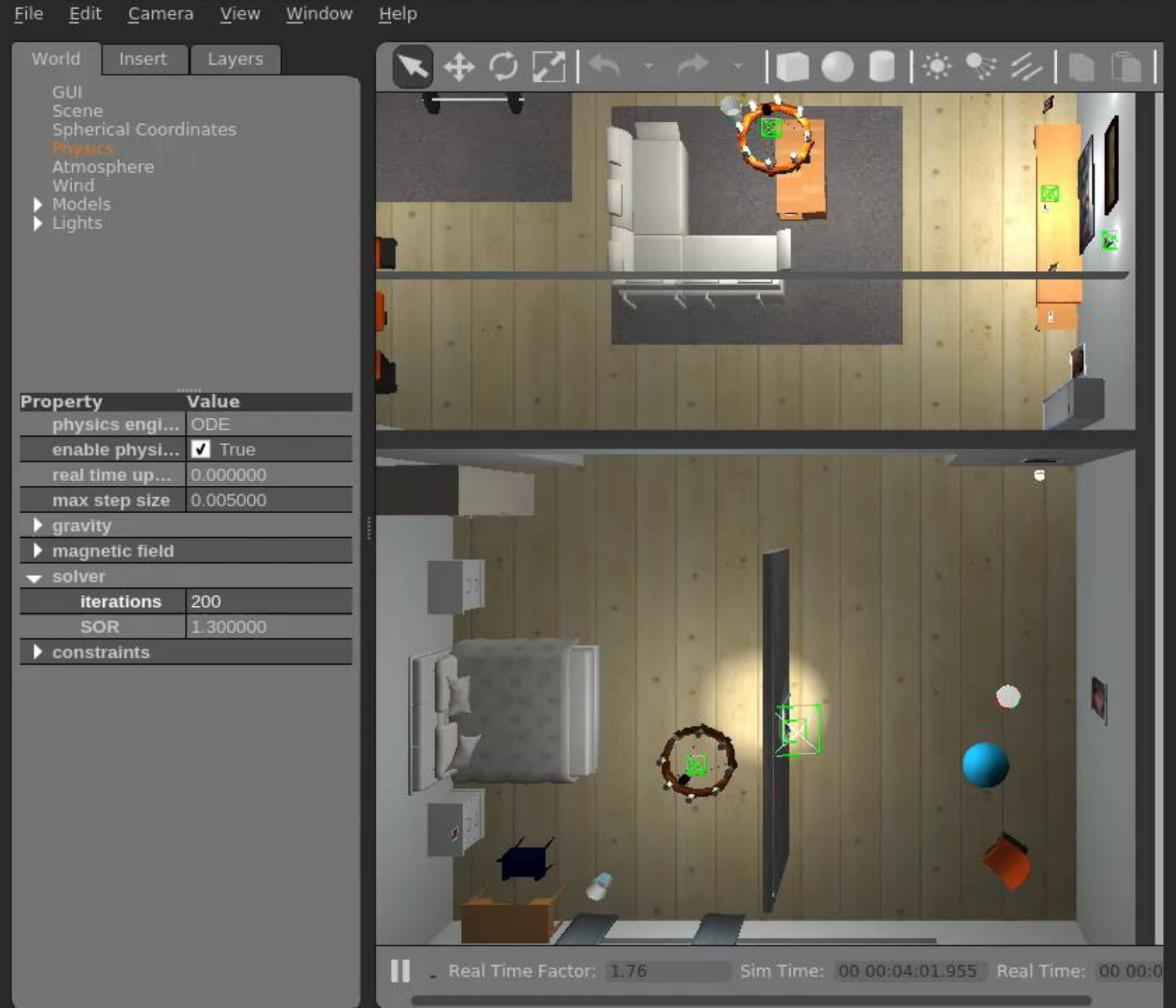
5,000 missions a month

Gating submissions

Catching issues

Higher quality mainline

Developers want more



Credit: Chris Kruger, iRobot



Test & Verify

multi-robot
simulations

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



Bastian Solutions uses RoboMaker to simulate multi-robot fleets

○ Problem statement

Bastian Solutions enables orchestration of a fleet of robots

Software testing currently requires physical robots; practical limitation of 8–10 robots in test lab

○ Use of AWS RoboMaker

AWS enabled simulation of a multi-robot environment with 35+ robots, thus enabling testing without physical robots

AWS services used: AWS RoboMaker, AWS IoT Greengrass, AWS Lambda

○ Business benefits

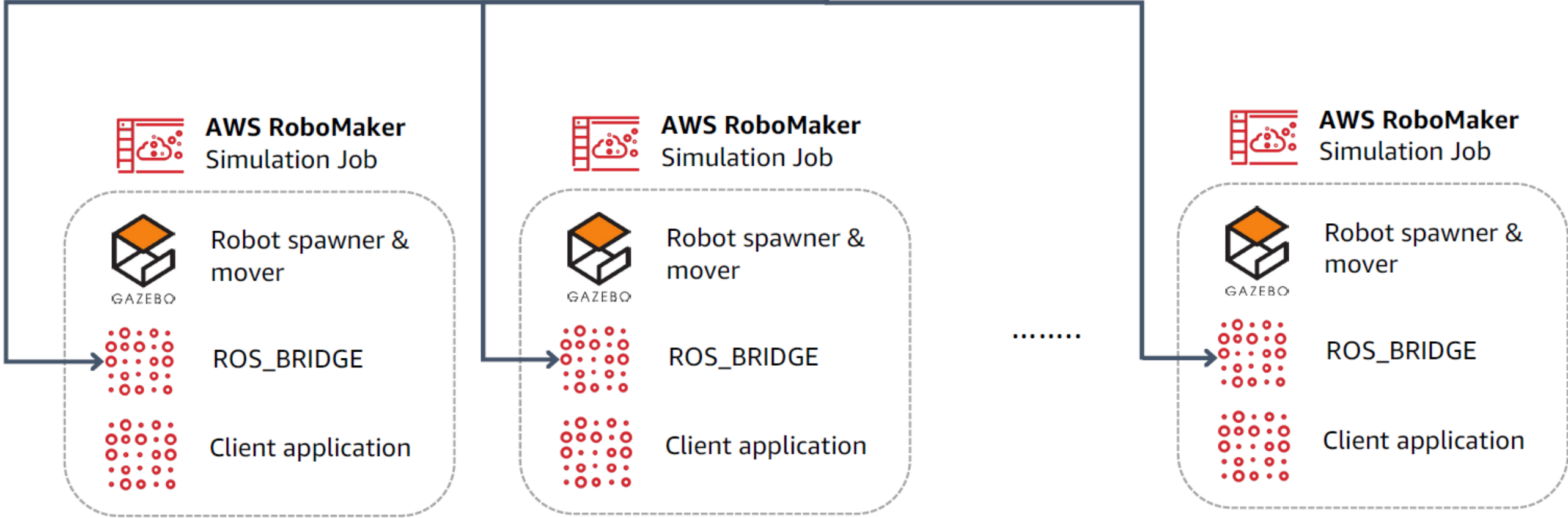
Bastian Solutions easily able to test application for larger environments without having to stand up physical devices



VPC



ROS Bridge Communication to Central Server over Web Sockets



Job: 1

Job: 2

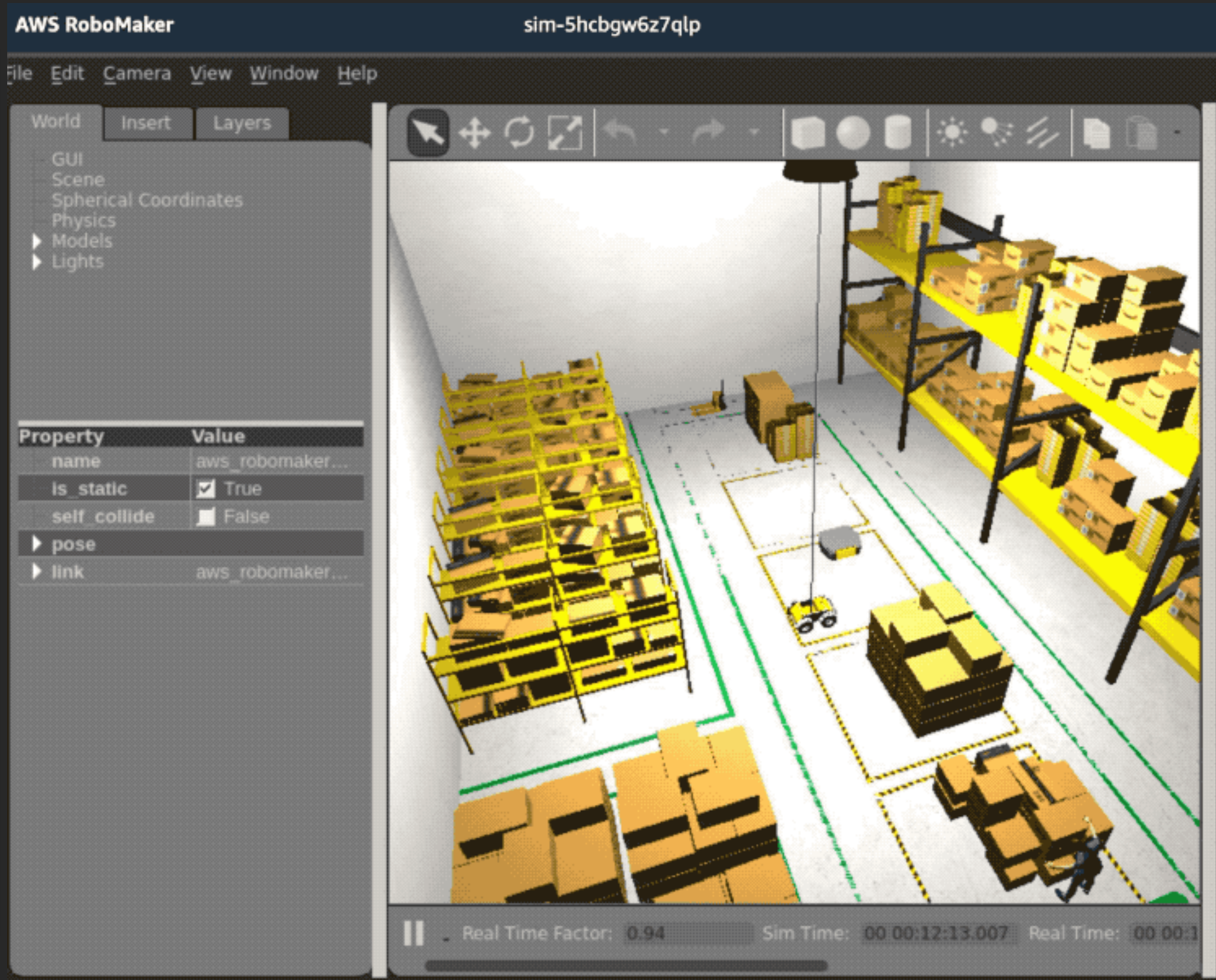
Job: N



AWS Lambda
 Launch (n) number of AWS RoboMaker Simulation Jobs, with various environment variables

Multi Robot Simulation

contact:
bargar@amazon.com
to discuss rqmts!

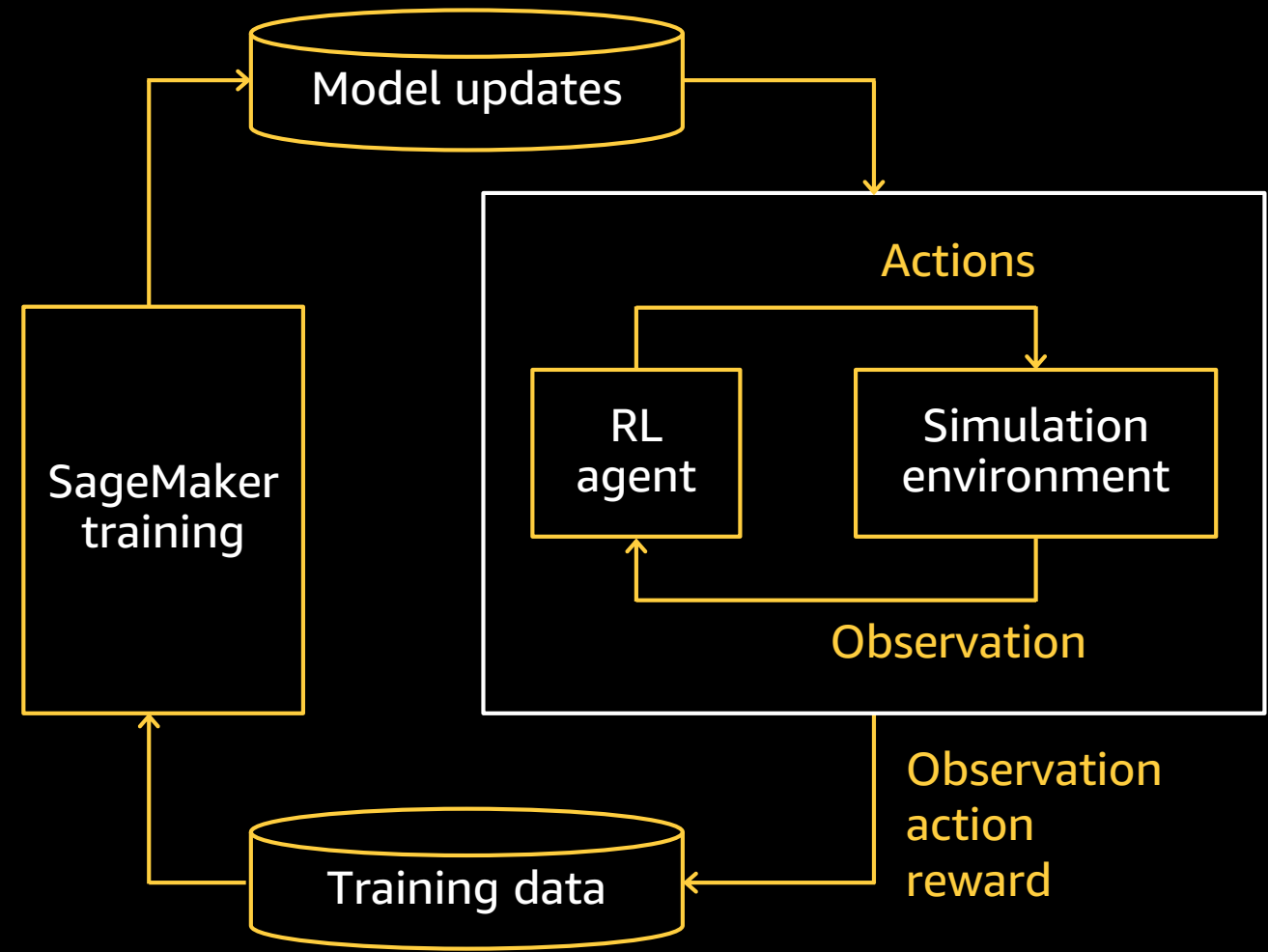
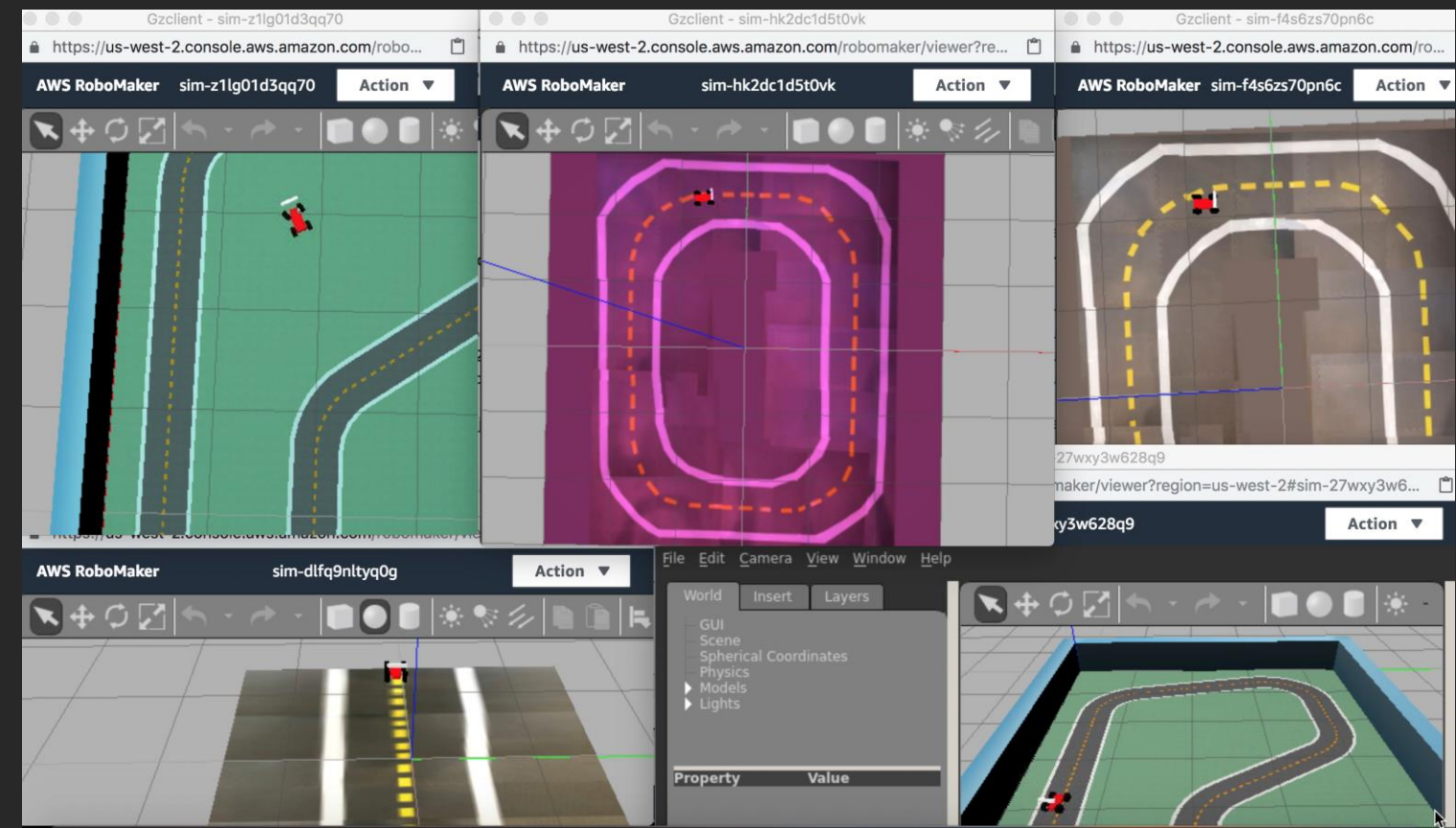


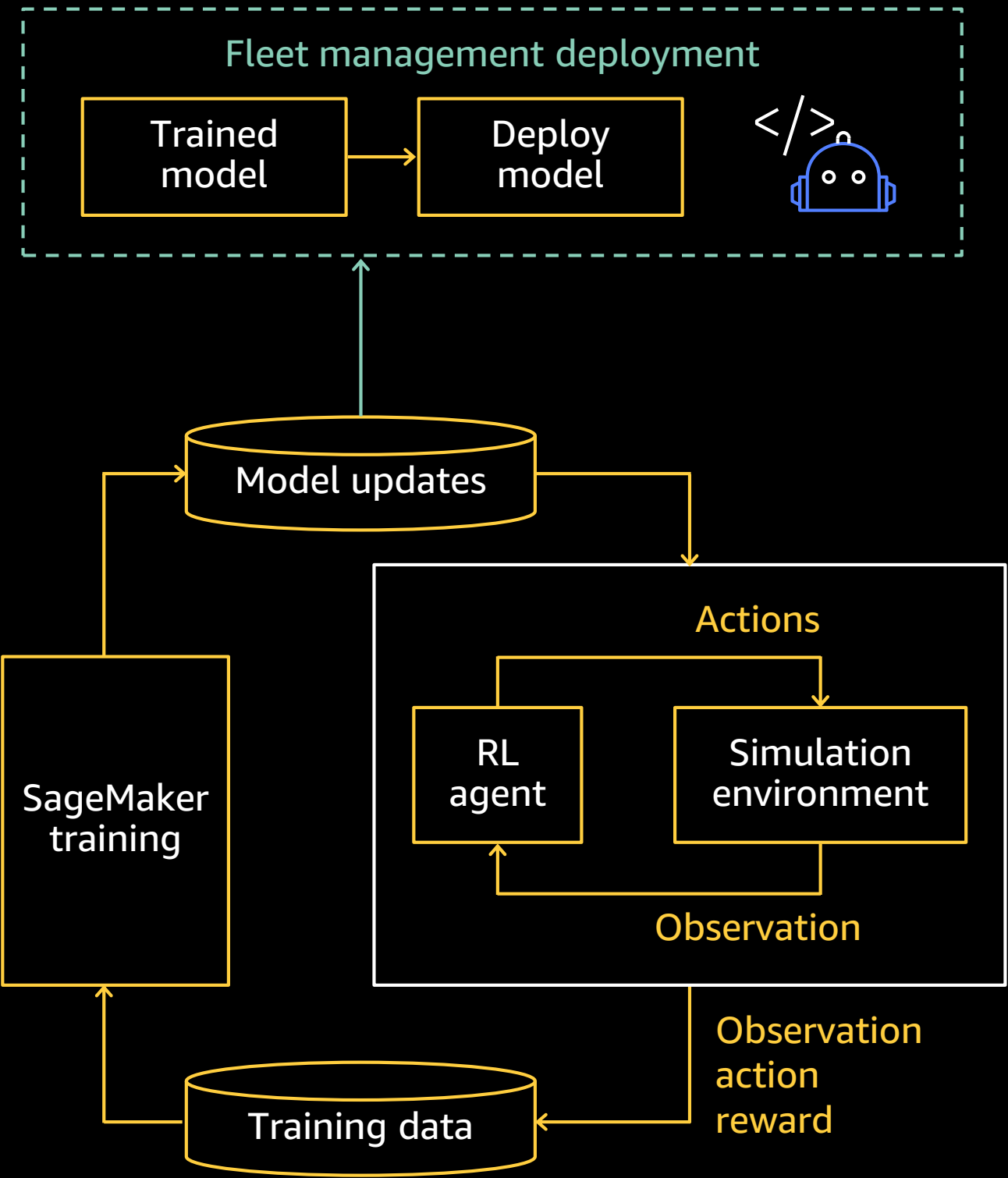
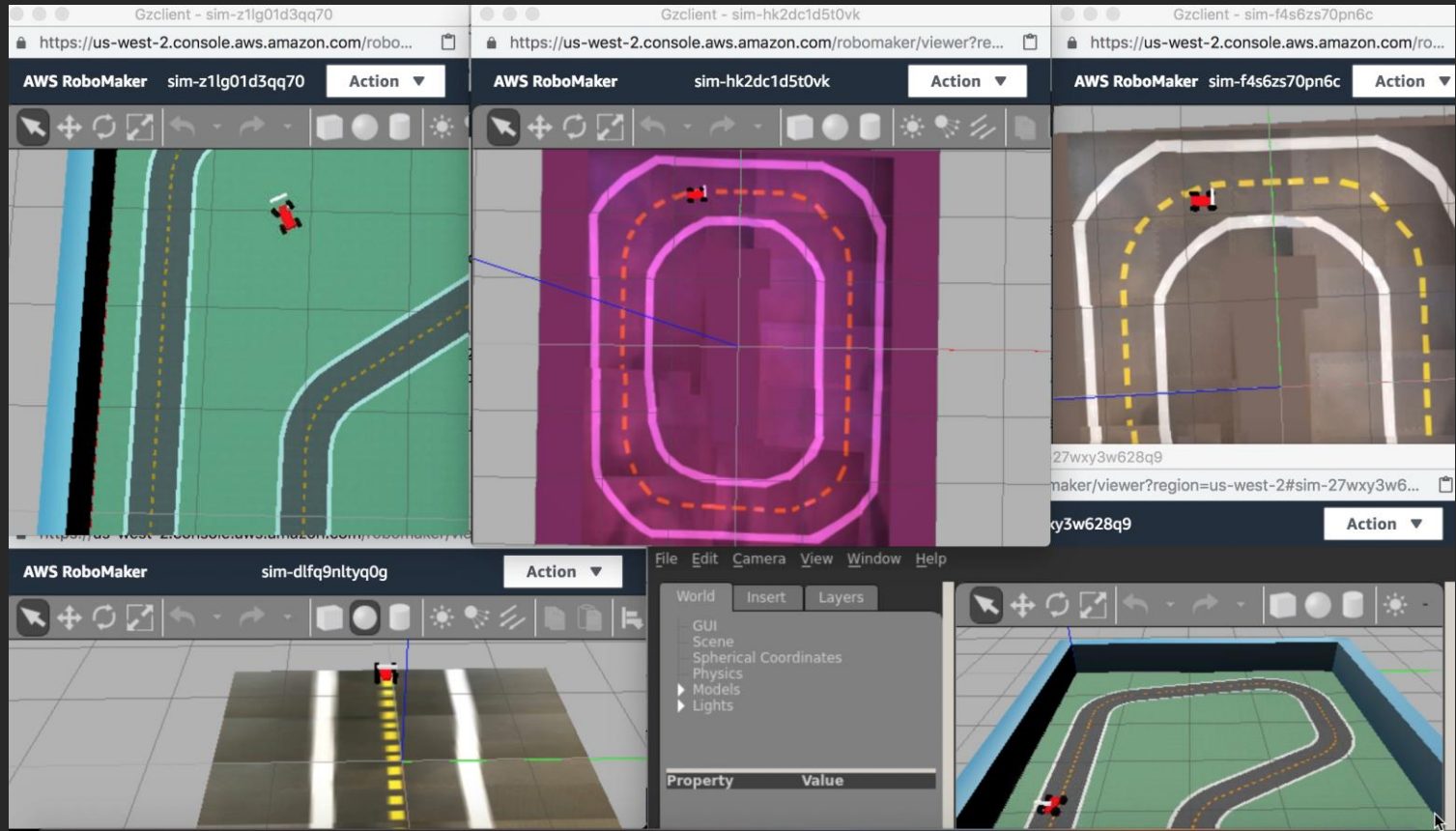
Simulation for Model Training

- Rapidly generate trial data in simulation to train reinforcement learning model
- Train reinforcement learning model natively in the simulation or in AWS SageMaker
- Run concurrent simulations to speed up training of a single model

AWS DeepRacer



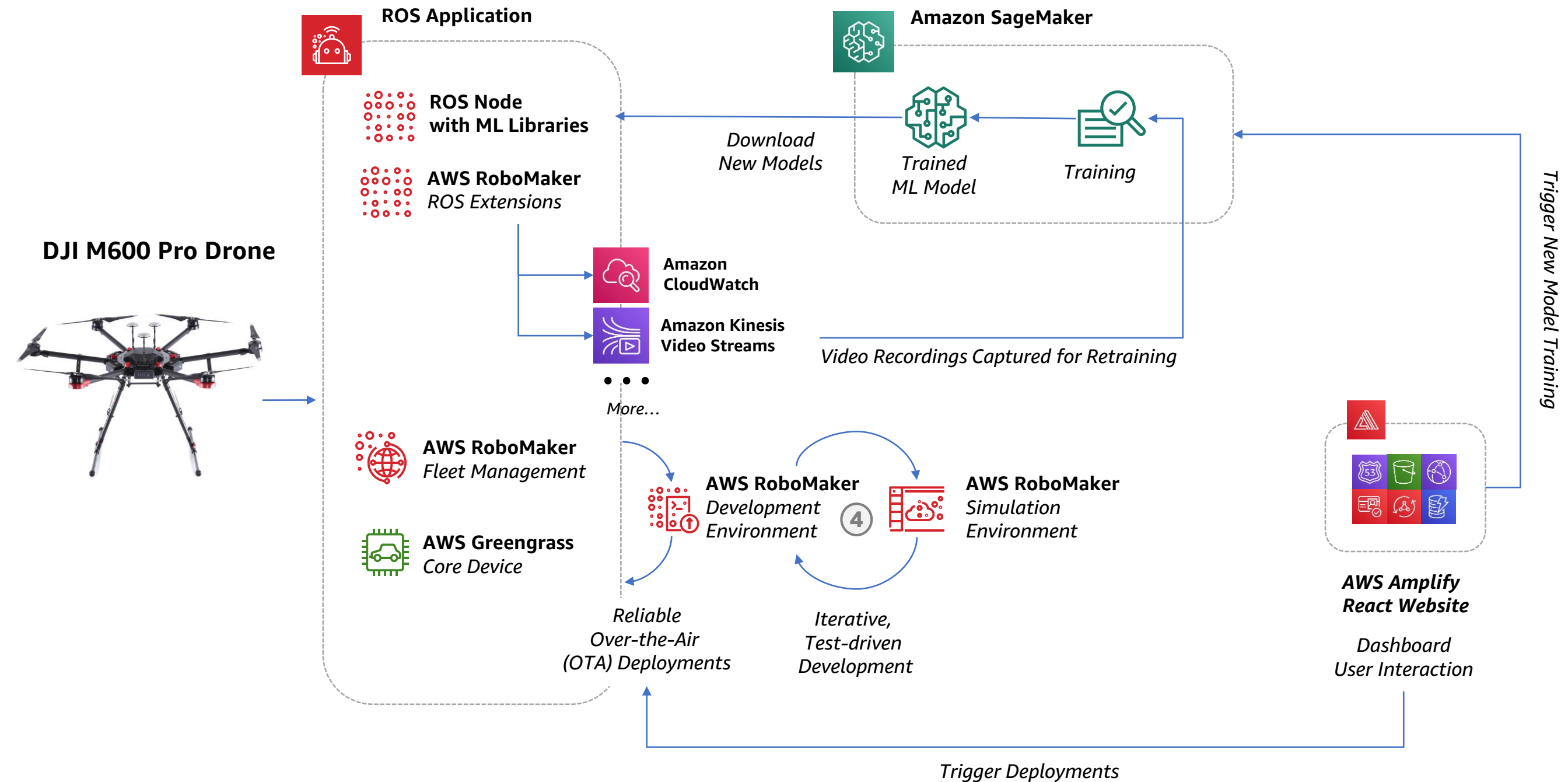




Successful Transfer from Simulation to Real World



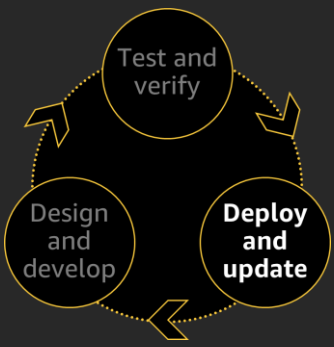
Remote Monitoring Drone



Robot Simulation Survey

*Please take this
short survey on
requirements
and desired
features for
simulation...*

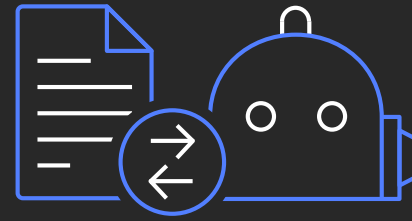
<https://tinyurl.com/rr6amyh>



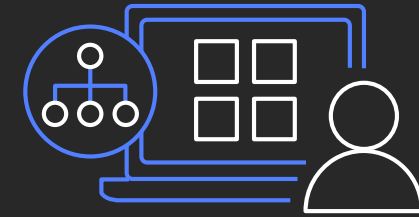
Deploy and Update at cloud scale



Ability to control deployments



Visibility to robot health



Deploy across multiple robot brands

Enterprises need greater command and control over robot assets

Deploy and Update

manage robots across
multiple brands

○ Problem statement

Enterprise customers are unable to easily manage a fleet of multiple AMR brands

Inability to orchestrate across AMR brands

Inability to share map information across robots

○ AWS RoboMaker and AWS cloud services

Enable a unified interface to orchestrate robots and share maps across multiple brands

○ Business benefits

Ability to plan a mission across robot brands and robot types

Deploy and Update

robot
registration,
over-the-air
deployment with
AWS RoboMaker

- Register robots with RoboMaker fleet management and organize them into fleets
- Deploy a robotics application into a robot fleet securely through just a few clicks
- Conditional over-the-air updates
- Fleet monitoring and alerting*
- Fleet deployment rollback*

** Coming soon*

Aptpod

Digital twin
environment for
AWS RoboMaker



aptpod

○ Fusion Data Streaming Hub “intdash”

Provide data handling edge agent, sever APIs and visualization dashboard for industrial fusion data streaming

Low latency bidirectional data streaming via cloud hub

Simultaneously data acquisition and data analytics pipelines

○ Telemetry and Teleoperation

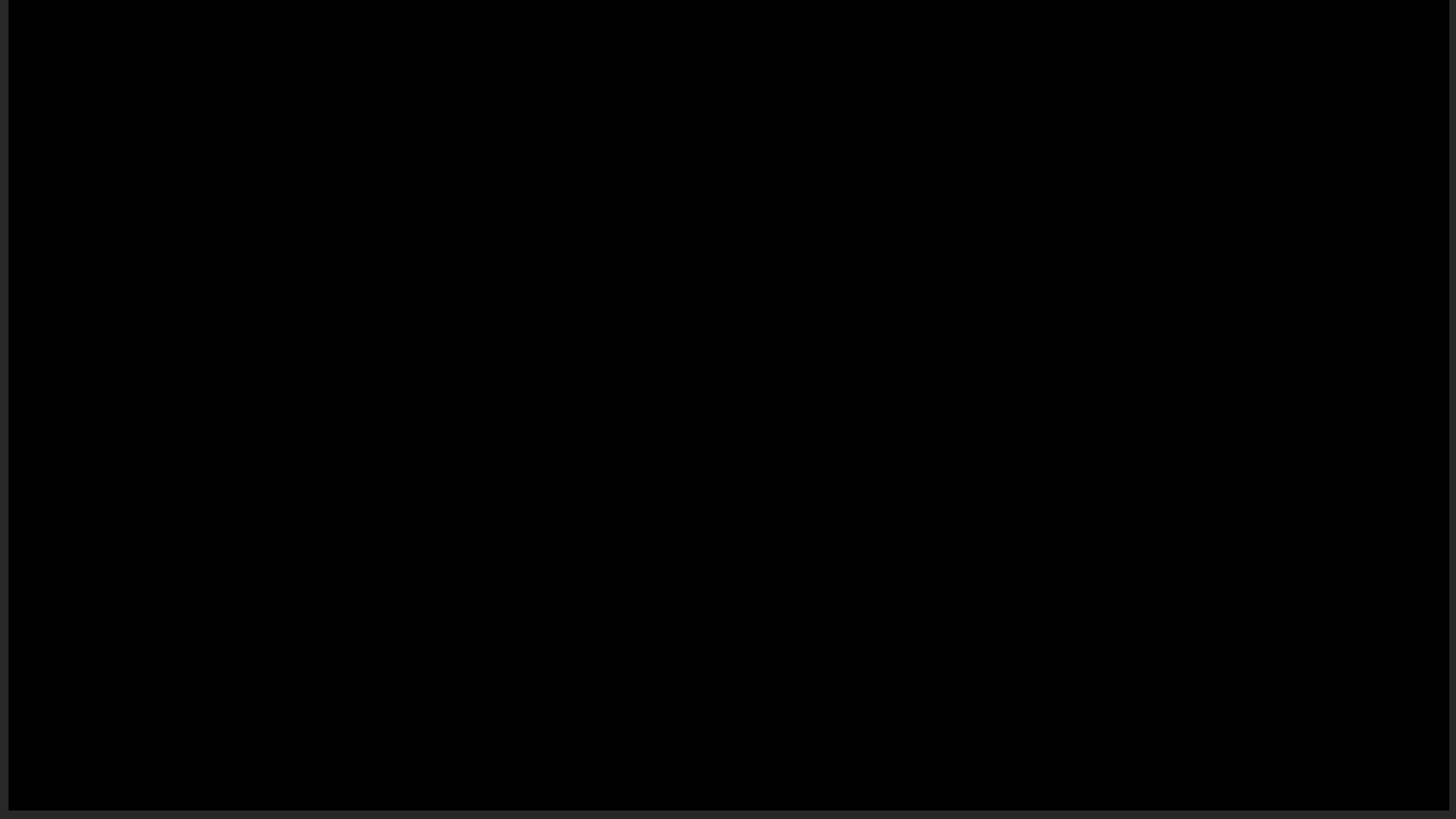
Rapidly develop Telemetry, Data Acquisition and Tele-operation functions into robots, simulation and physical environment

○ User benefits

Machine learning pipelines

“intdash” enables data acquisition of ROS messages

Data orchestration for machine learning on Amazon SageMaker



Role of the Cloud

- 1 Intelligent cloud services can enhance local processing on the robot and improve performance over time.
- 2 Simulation can be used to test application correctness, and ensure performance across a range of conditions.
- 3 Simulation, combined with reinforcement learning, can be used to program robot actuation.
- 4 Cloud services enable developers to build applications for their business, end-to-end, that include robotics.

Questions?

