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re:Invent
NOV. 28 – DEC. 2, 2022 | LAS VEGAS, NV

IOT304-R

Building a smart city for Buenos Aires city government

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BA City Gov | Mobility & Technology

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AWS

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Agenda

Vision of a smart city: Buenos Aires City, Argentina

Transnational collaboration among NEC, AWS, and Buenos Aires City Government

Unpack a smart city ML solution

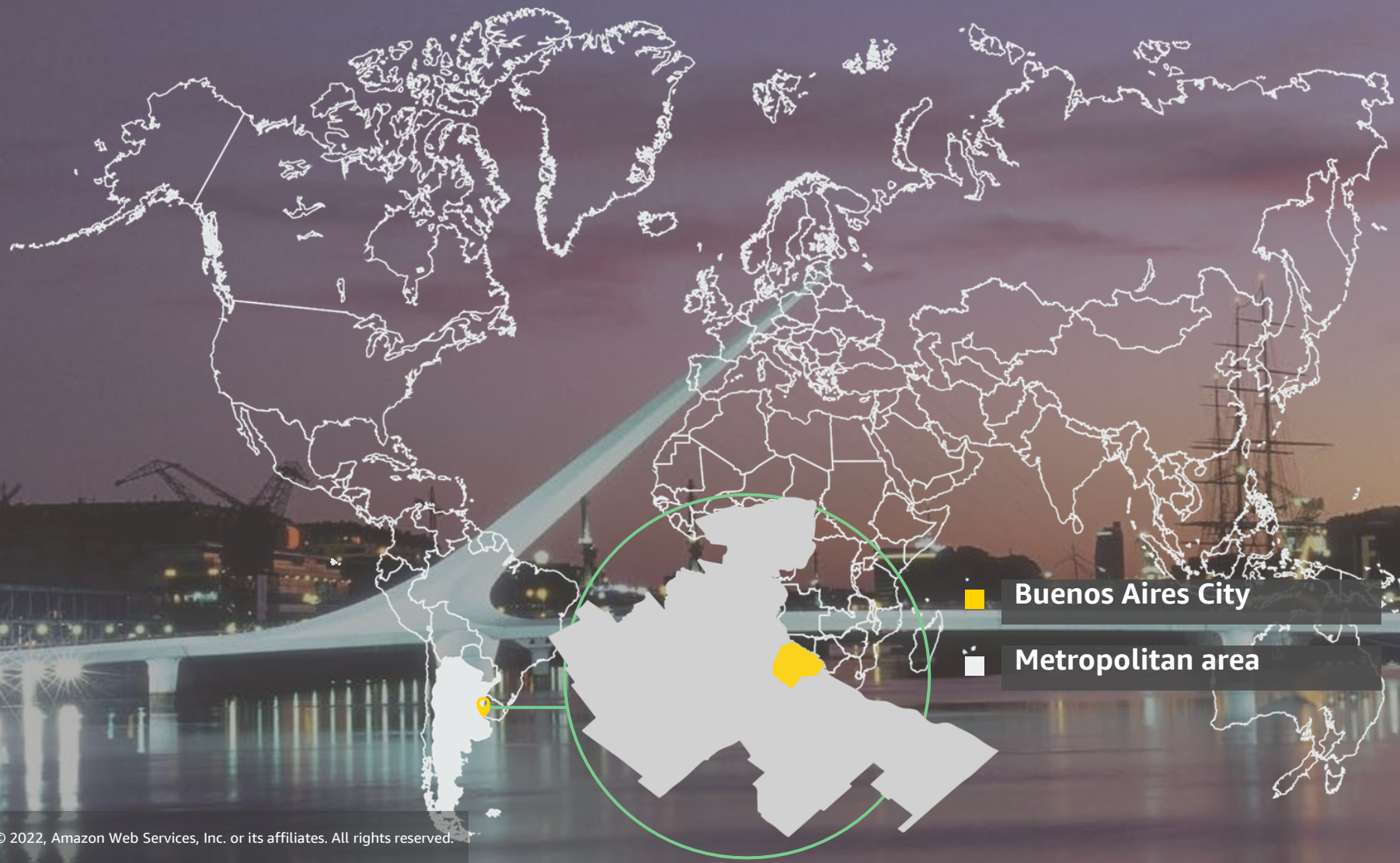
- ML Models
- Application
- IoT fleet management
- MLOps and CI/CD

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Vision of a smart city: Buenos Aires City, Argentina

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City of Buenos Aires
Argentina



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Metropolitan area of Buenos Aires

31% 

Represents 31% of the national population

15M

Residents

3M

The city has a resident population of 3 million people

9M

9 million daily trips that start or end in the city

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Vision zero – Objective

Target

To reduce road fatalities and serious injuries
-50% by 2030

Fatalities within 7 days

2015 yr.	2019 yr.
153	103

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Road safety plan 2019–2023

2nd Buenos Aires City Road safety plan

2019–2023

Infrastructure

Enforcement and technology

Education and communication

Citizen engagement

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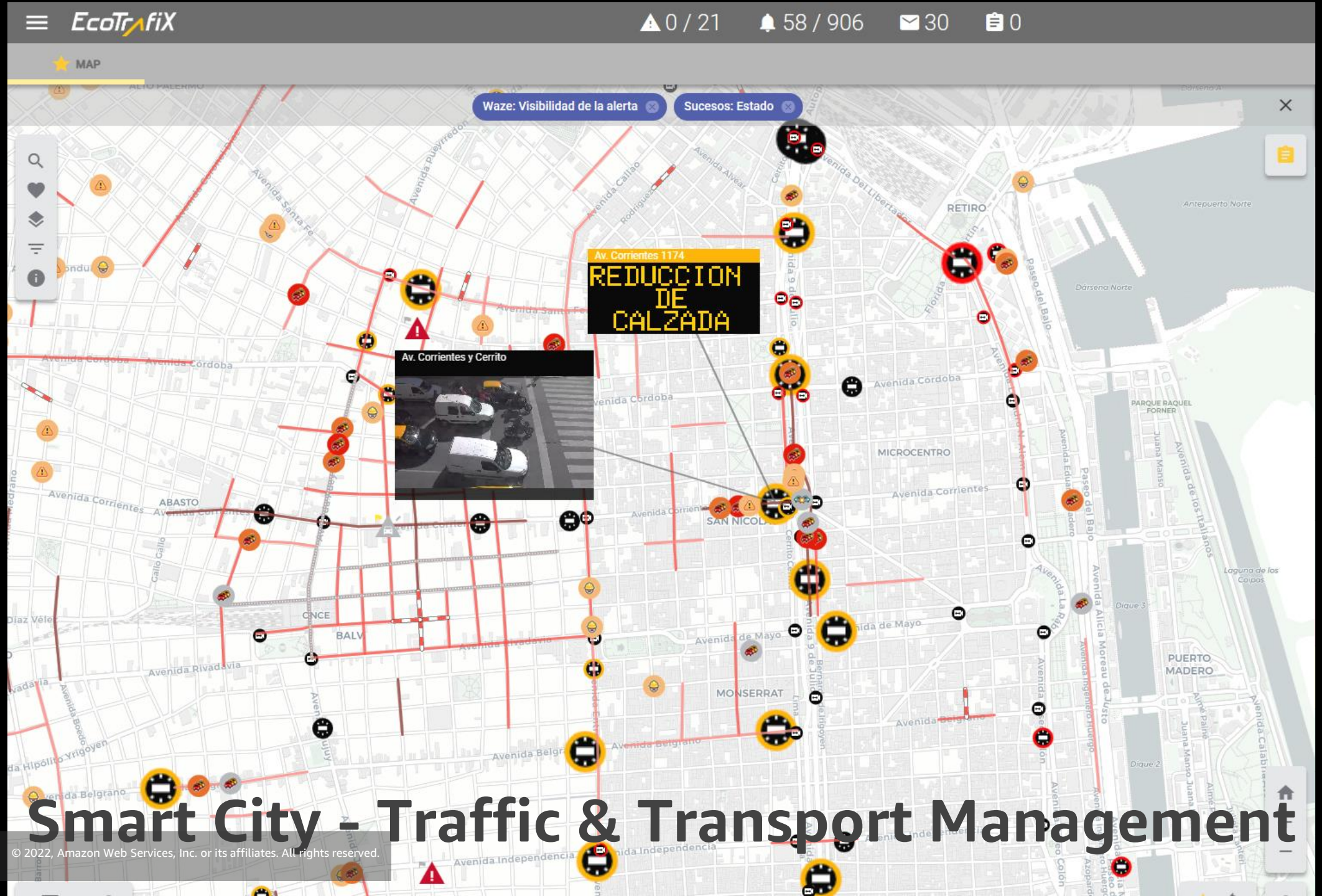
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Smart city – Traffic and transport management

- Traffic Devices
- Public Transport
- Traffic Enforcement

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Smart City - Traffic & Transport Management

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AWS collaboration with NEC

Infrastructure and processing

High quality images

Open software and hardware

On the edge processing



Industrial PC: Intel i7 10th gen VEGA 330-02A1 with two Intel Movidius Miriad X

Camera: 5 Megapixels 30 FPS max IR Illuminators

Network: 4G cellular using VPN

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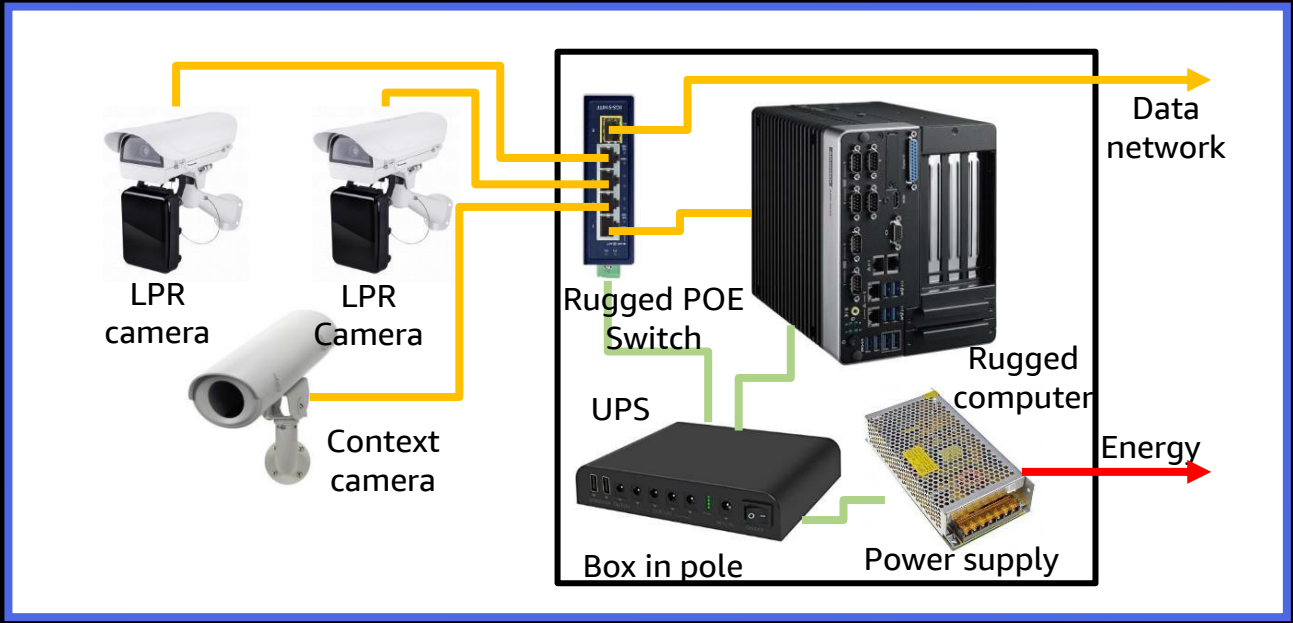
AWS collaboration with NEC

PROCESS OF ENGAGEMENT

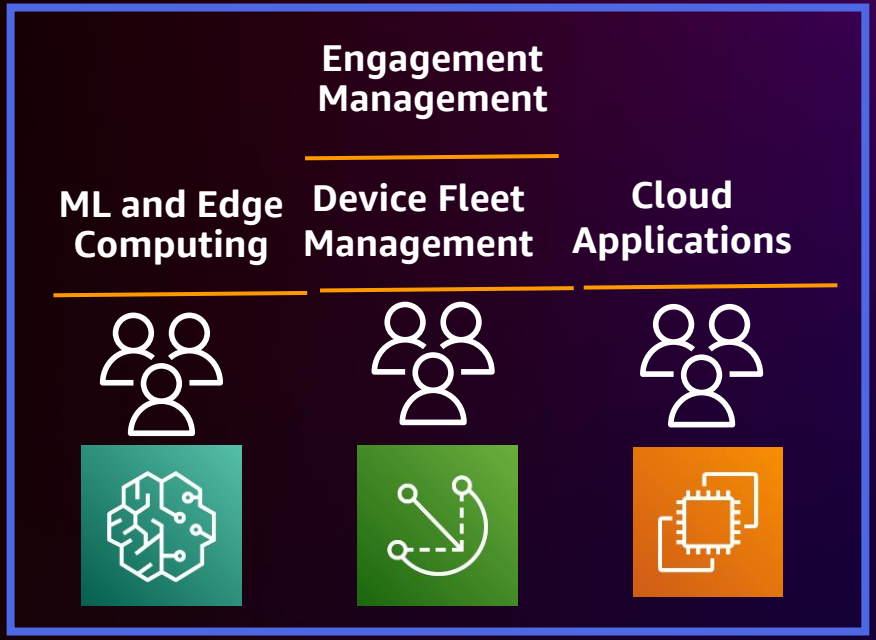
Buenos Aires City Government



NEC



AWS teams

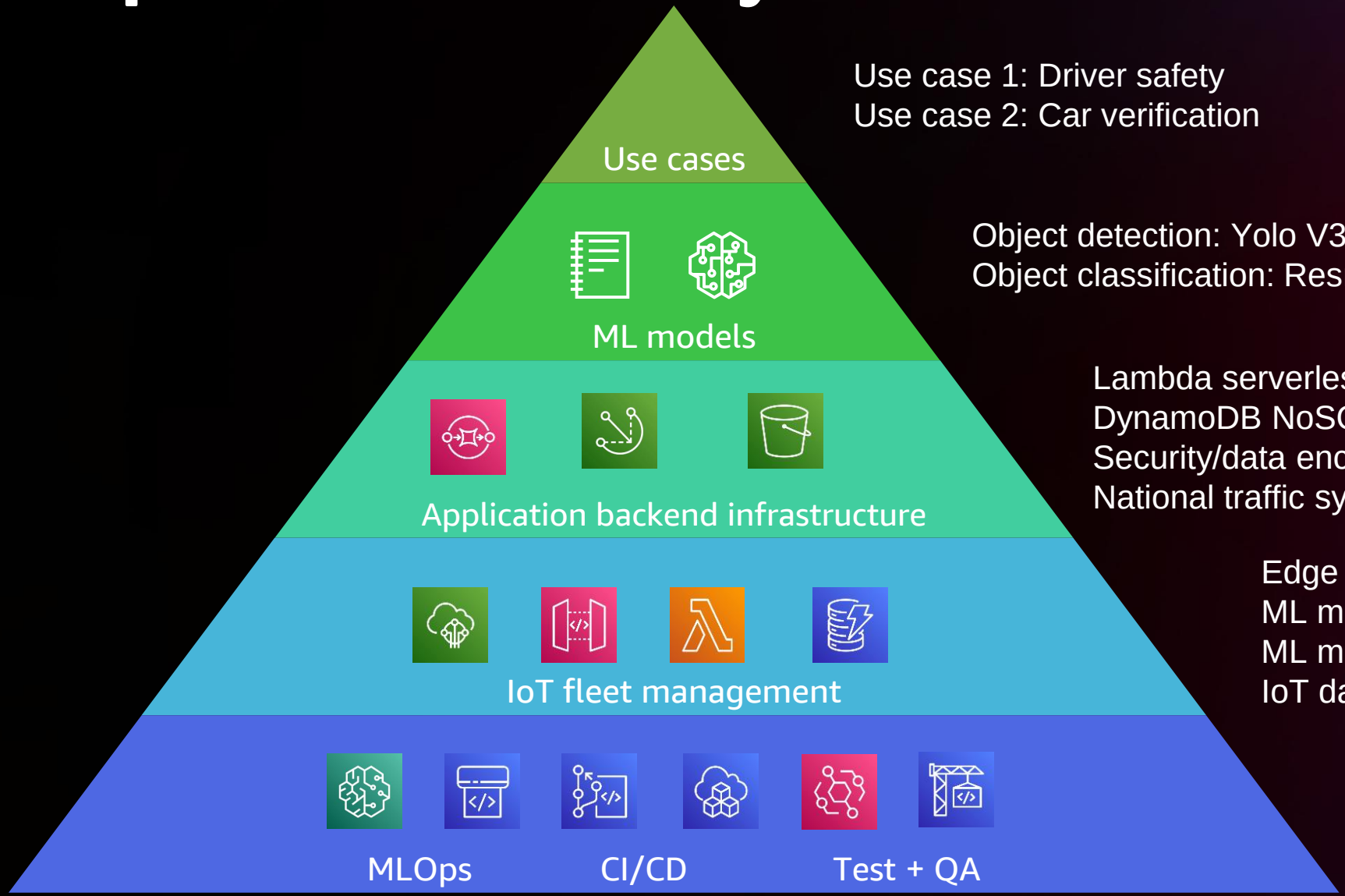


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Unpack a smart city ML solution

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Unpack a smart city ML solution



Use case 1: Driver safety
Use case 2: Car verification

Object detection: Yolo V3 model
Object classification: Resnet 50

Lambda serverless backend
DynamoDB NoSQL database
Security/data encryption
National traffic system API integration

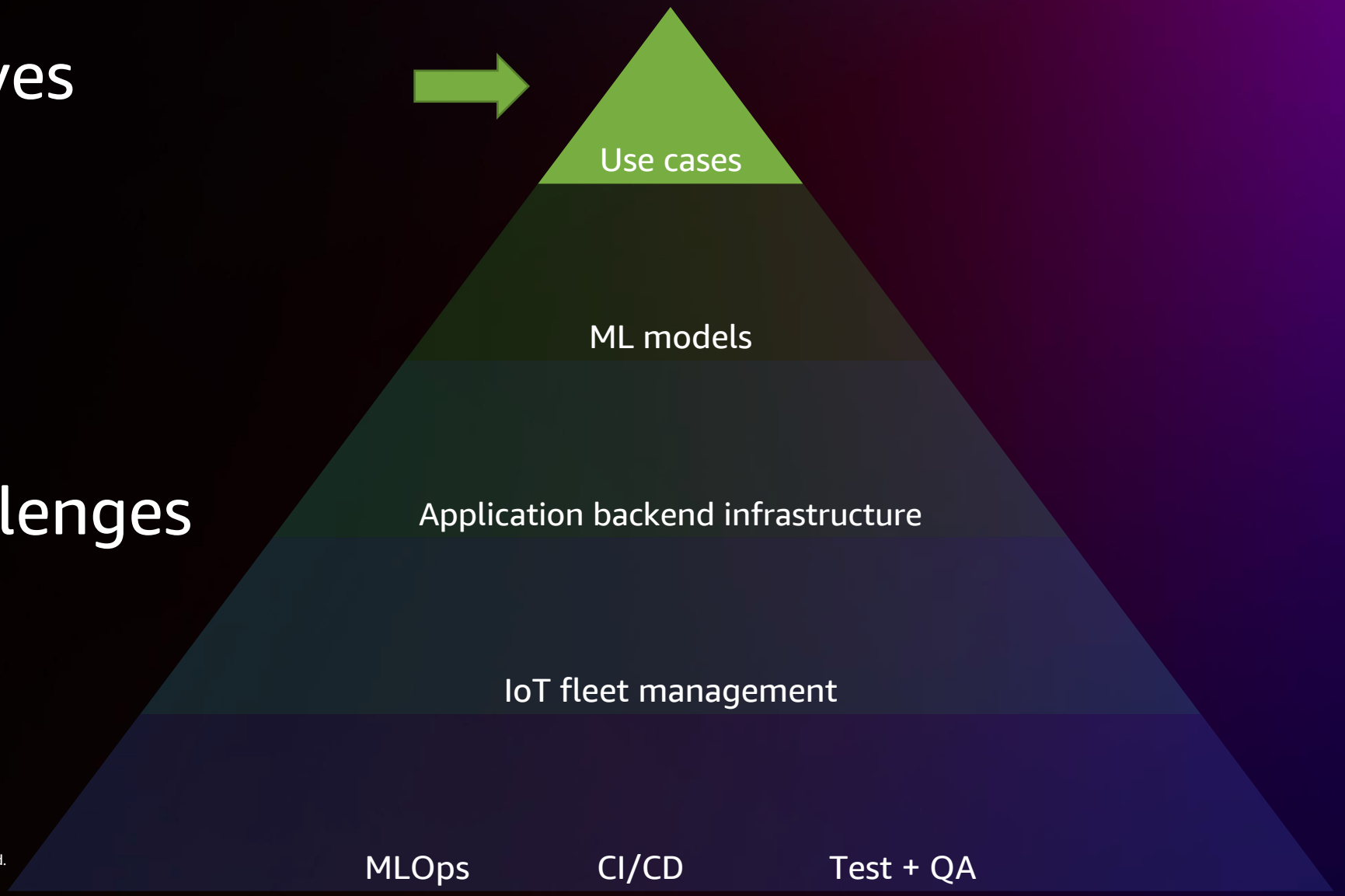
Edge device provisioning
ML model deployment to edge device
ML model monitoring
IoT data ingestion

ML model retraining + registry
Automated model deployment
DevOps tools
QA system tests

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Unpack a smart city ML solution

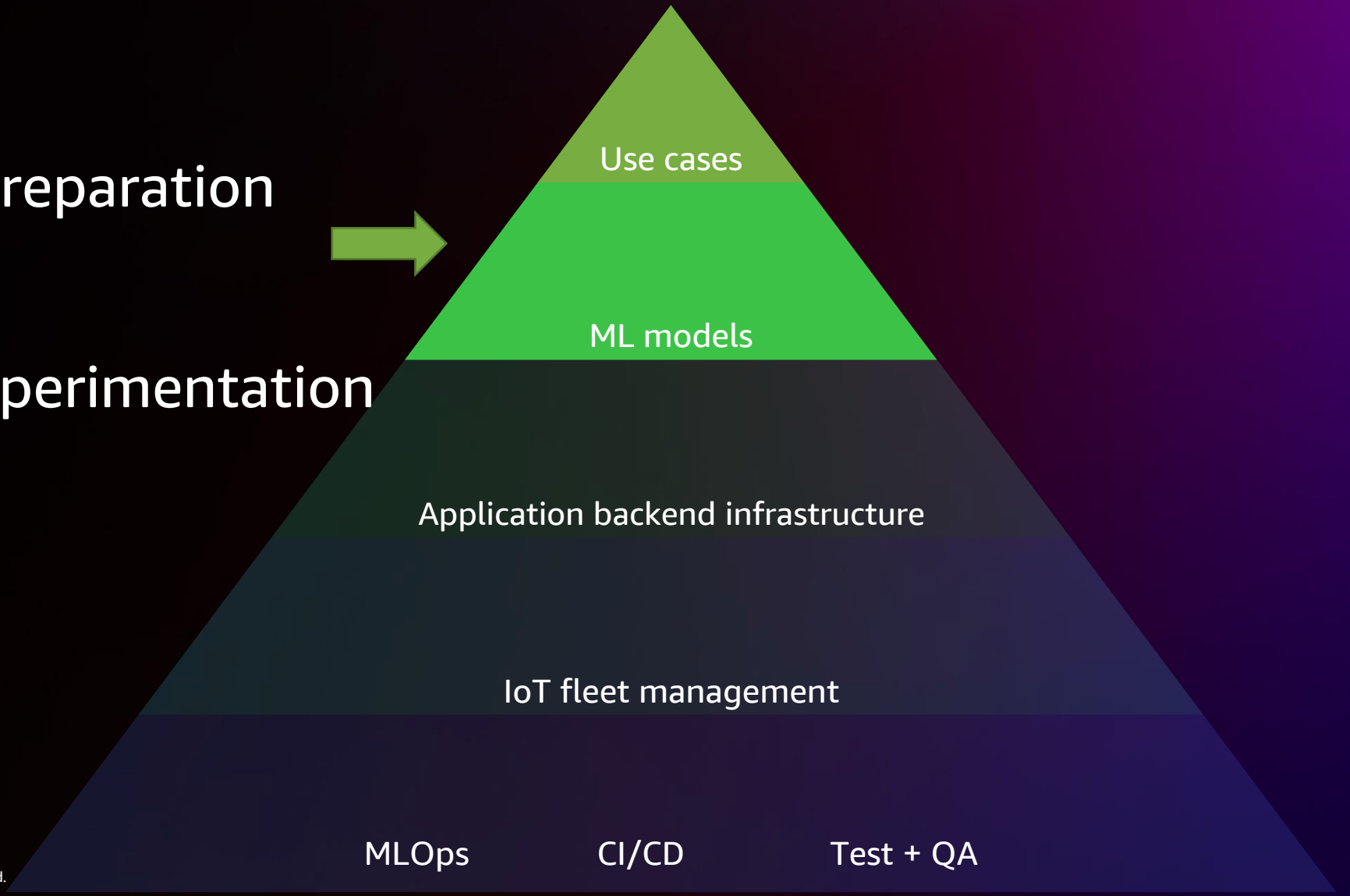
- Business objectives
- MVPs
- Success metrics
- Existing system
- Constraints/challenges



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Unpack a smart city ML solution

- Data acquisition
- Data exploration/preparation
- Feasibility test
- Model selection/experimentation
- Model evaluation



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Use case 1: Driver safety

Goal: Determine from traffic videos

- If drivers are wearing safety belts
- Cell phone usage

Success criteria

- Increase in traffic violation detection by x%
- False detection < x%



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Use Case 1: Driver safety

Challenges

- Multiples cars
- Lighting conditions/bad weather
- Glass glare/partial view
- Privacy of passengers
- False positives (GPS usage, passenger cell phone usage, seat belts not visible on dark clothing)







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Data exploration/preparation

SAGEMAKER GROUND TRUTH + MECHANICAL TURK

Dataset object summary



Source

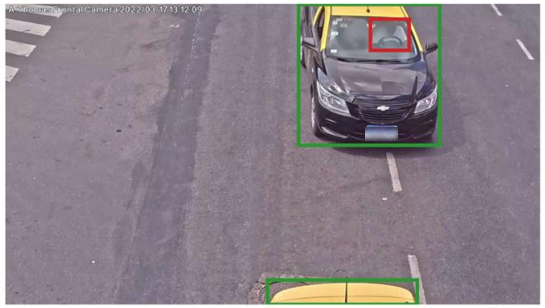
s3://datasets-vehiculo-seguridad-cinturon-celular-[redacted]886.jpg

Labels (3)

Search by label name

Label name	Source	Confidence
car	Human annotated	
car	Human annotated	
no_belt_driver	Human annotated	

Dataset object summary



Source

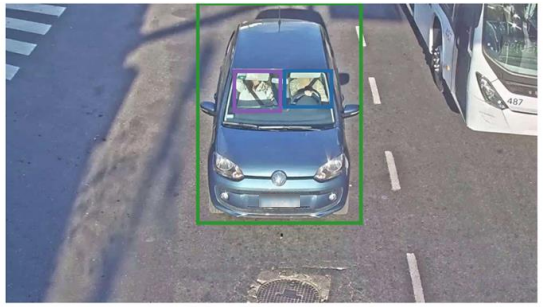
s3://datasets-vehiculo-seguridad-cinturon-celular-[redacted]1403-471.jpg

Labels (3)

Search by label name

Label name	Source	Confi
car	Human annotated	
car	Human annotated	
driver_with_phone_using	Human annotated	

Dataset object summary



Source

s3://datasets-vehiculo-seguridad-cinturon-celular-[redacted]1044-732.jpg

Labels (3)

Search by label name

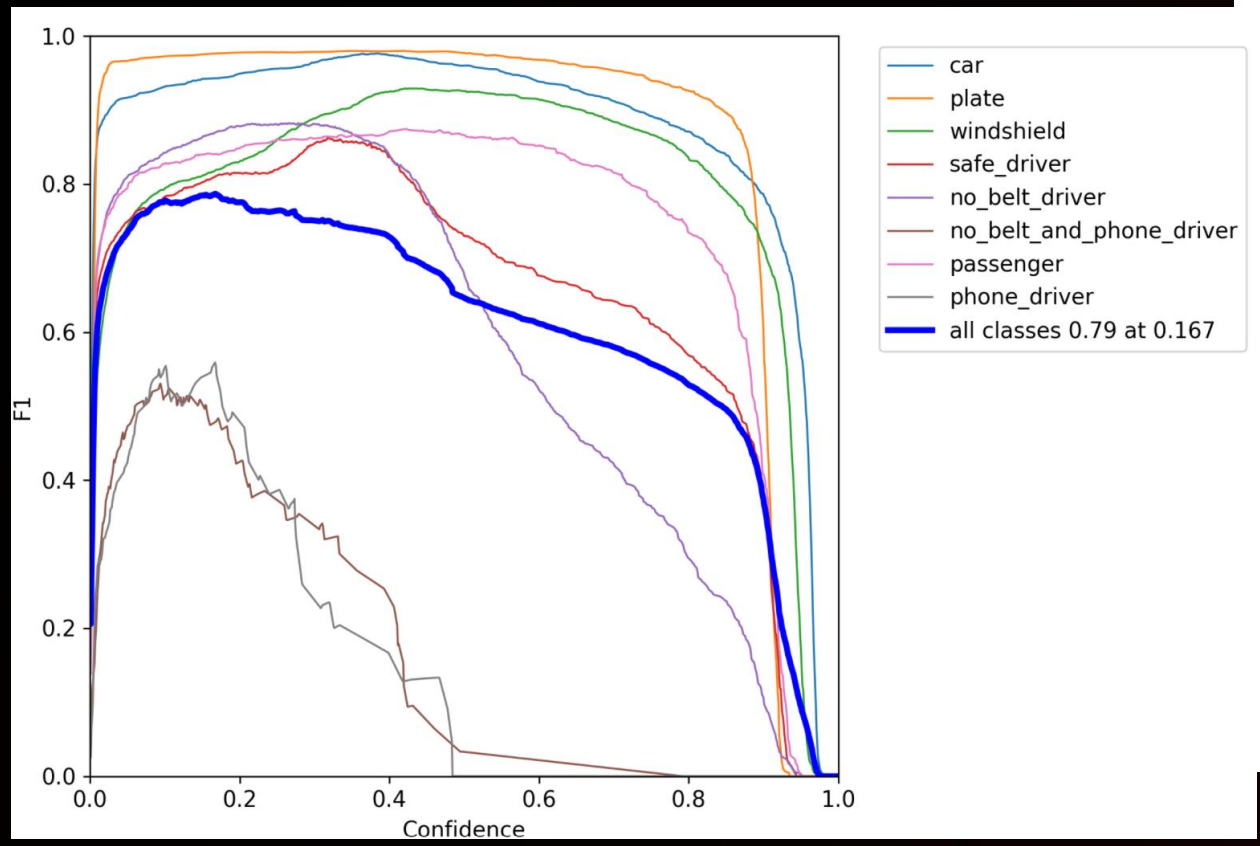
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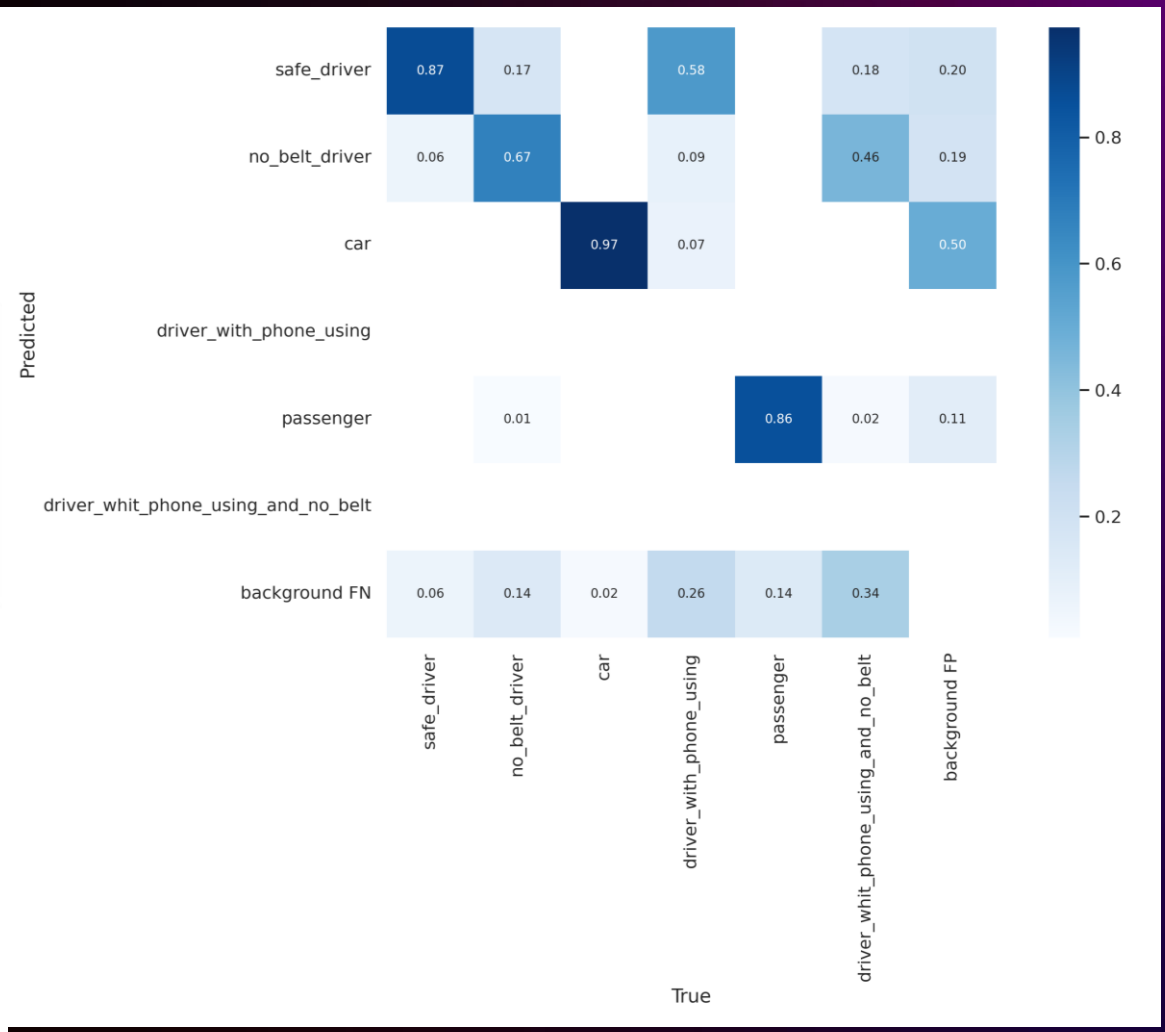
Label name	Source	Confidence	Task type	Label creation time
belt_driver	Human annotated		Bounding box	May 10, 2022, 10:30 AM UTC
car	Human annotated		Bounding box	May 10, 2022, 10:30 AM UTC
passenger	Human annotated		Bounding box	May 10, 2022, 10:30 AM UTC

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Model evaluation

Model type	Inferencing latency
Yolo V3	< 30ms

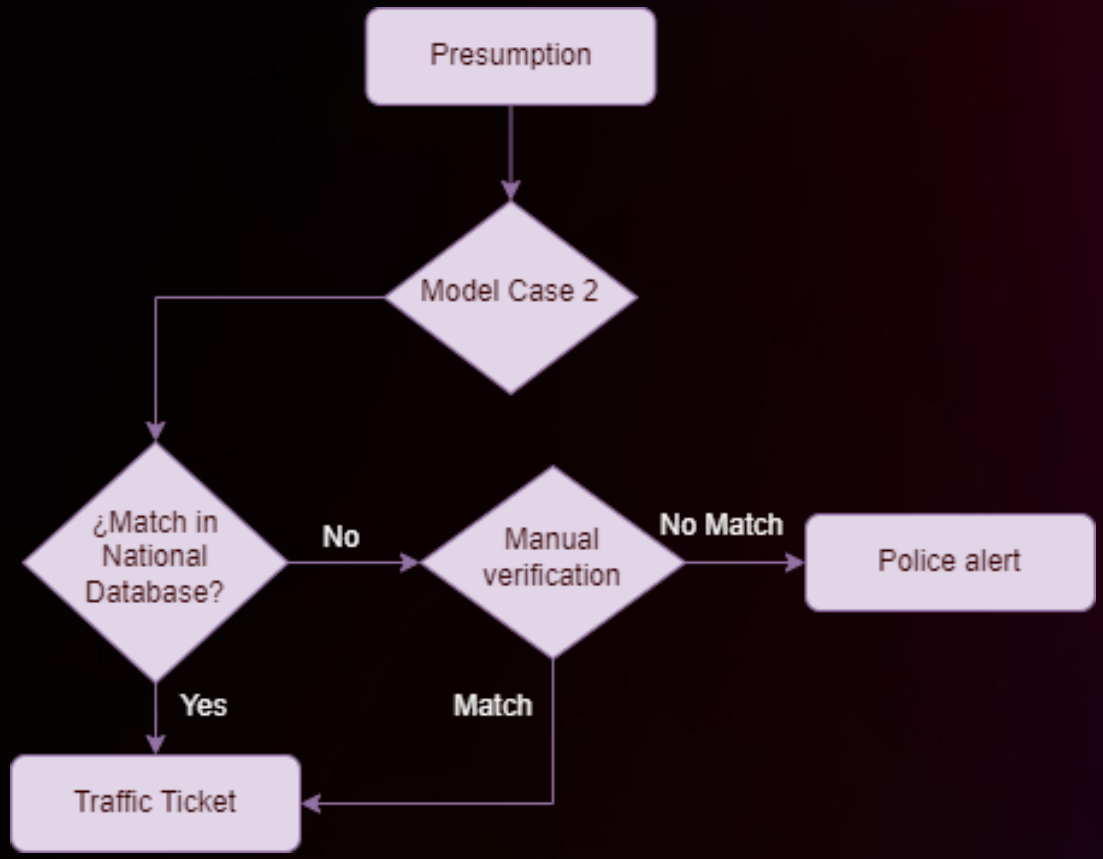




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Use case 2: Car make verification

Business objective: Detect fake license plate, car theft
Goal: Verify car make/model based on license plate registration in national database



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Use case 2: Car make verification

Challenges

- Too many car models
- Hard to acquire training dataset
- Different angles
- Lighting conditions
- Car paint/logos
- Overlapping cars











Success metric

- Increase monthly violation detection by x%

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Data exploration/preparation

Challenge with getting the right dataset

- Lack of data

Mitigations

- Online open-source dataset
- Search engine + web crawler





Public dataset





Reality

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Data exploration/preparation

- Challenge with getting the right dataset
  - Unlabeled data

Mitigations

- Automated search and label in national database
- SageMaker Ground Truth + Mechanical Turk

Raw images from street → Yolo model crop out car bounding boxes and recognize license plate → Compare license plate with national database to get car make → Split labeled images into train/val/test dataset



License plate recognitions:
XX123 YY
XX567 ZZ

National database lookup:
XX123 YY: Fiat Fiorino
XX567 ZZ: Ford Focus

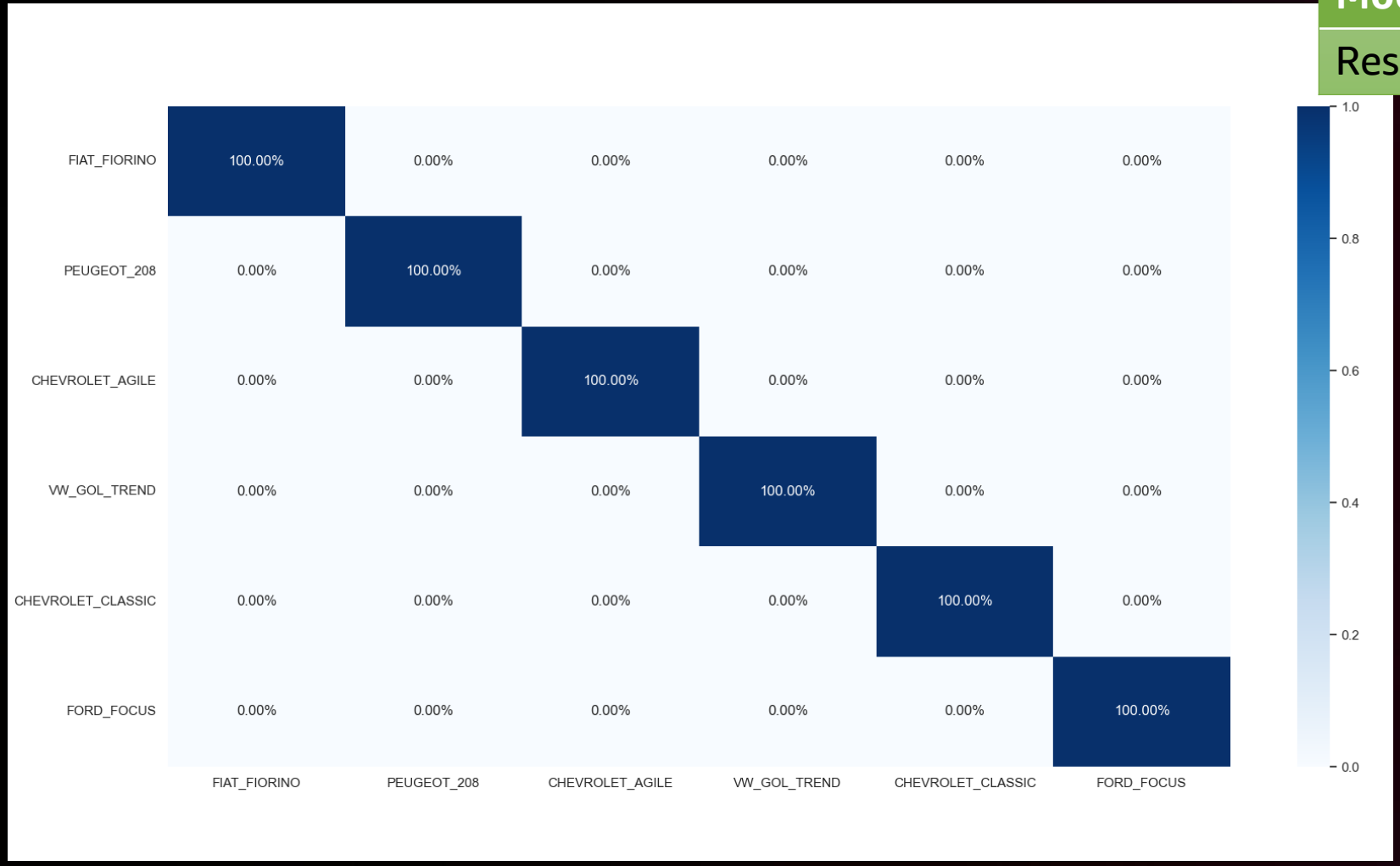
Generated labels:
Ford Focus



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Model evaluation

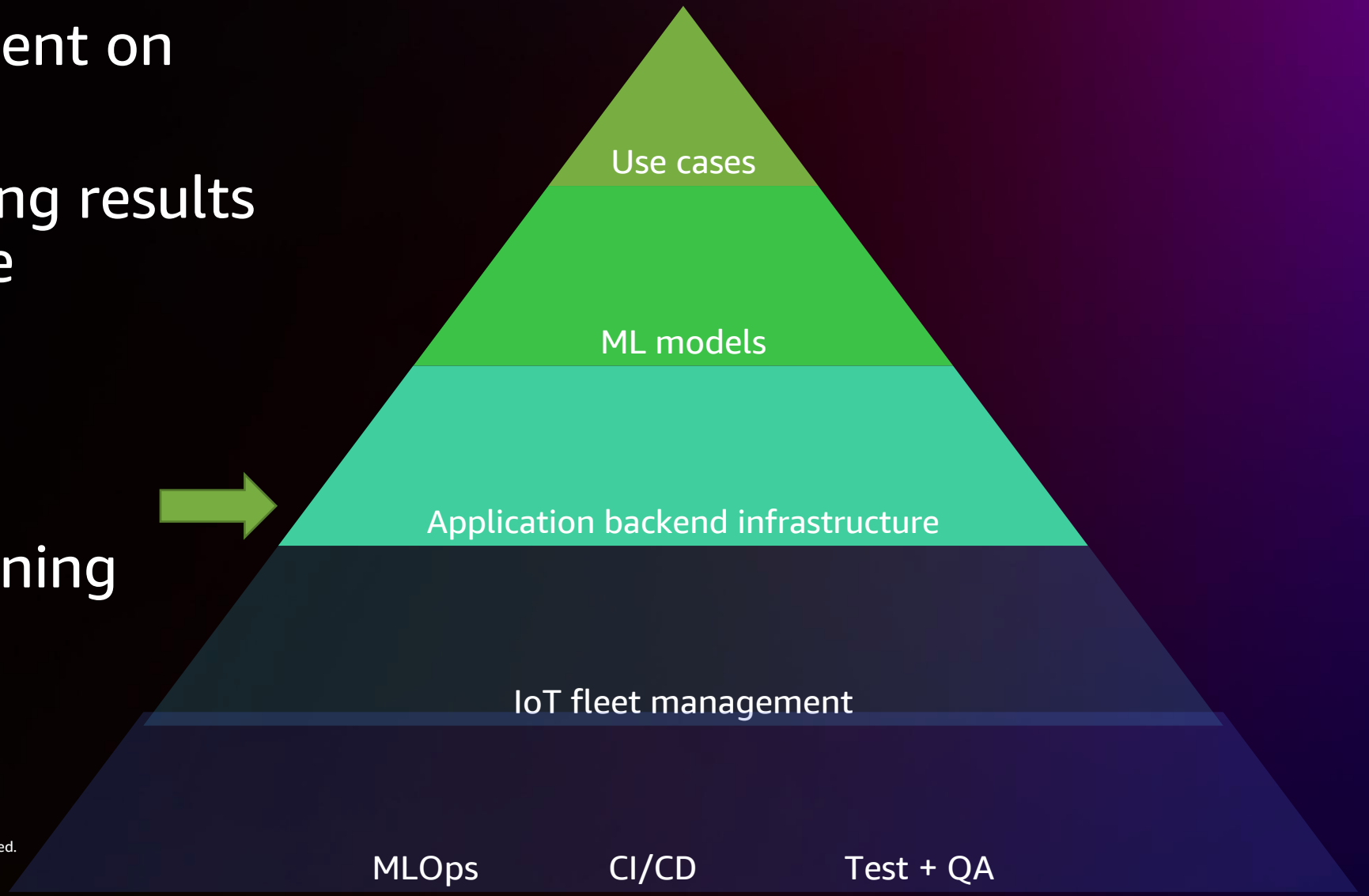
Model type	Inferencing latency
ResNet 50	< 30ms



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Unpack a smart city ML solution

- Inferencing component on edge appliance
- Publishing inferencing results to national database
- Handle batch IoT message ingestion
- Raw image sampled upload for ML retraining



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ML inferencing application

Why ML inferencing at the edge?

- Intermittent internet connection
- Fast video stream frame rate
- Cost saving (not all of the video frames contain information)

Edge device inferencing constraints

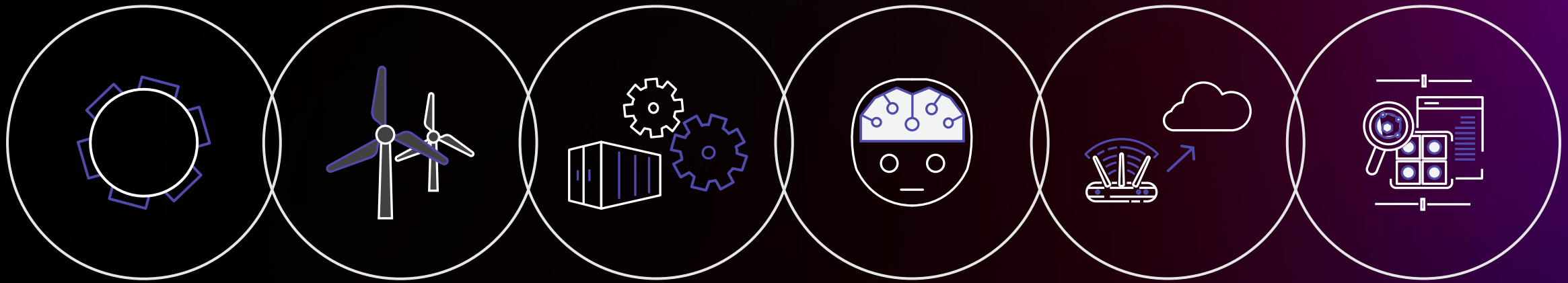
- Limited computation power and memory
- CPU-only device
- Different OS dependencies: Windows OS + Windows subsystem for Linux (WSL)
- Multiple models running on same device

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AWS IoT Greengrass edge capabilities

Device software



Local messaging

Enable pub/sub device communication through local MQTT broker; no cloud connection required

Data and state sync

Devices offline & synchronize data when reconnected using choice of protocol

Lifecycle management

Manage lifecycle app from cloud or locally – deploy, restart, stop, update, auto-restart on failure

ML inference

Train models using SageMaker (or other services), deploy, and run ML Inference locally with MXNet, TensorFlow Lite, SageMaker Neo, SageMaker Edge Manager

Stream manager

Collect, process, and export high-volume data streams from edge devices

Secrets manager

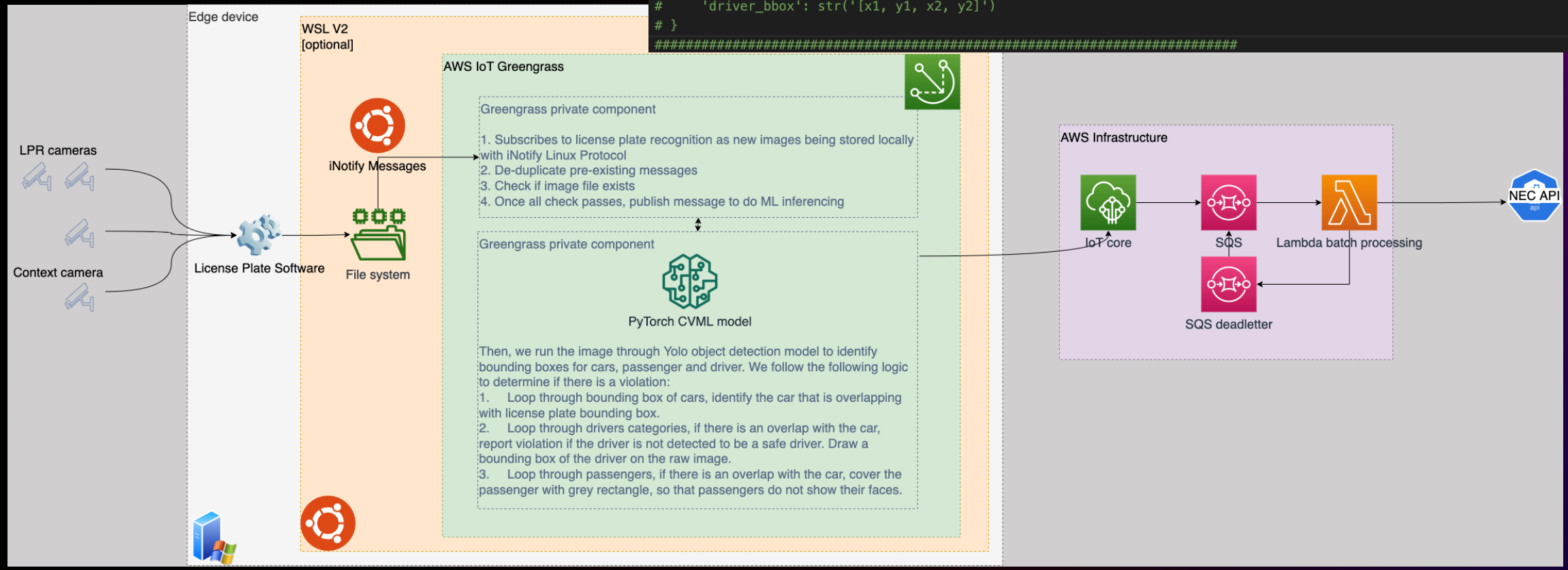
Store, access, rotate, and manage secrets locally from the cloud – credentials, keys, endpoints, and configurations

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ML on edge device

```
#########################################################################
# sample_payload = {
#     'original_file_path': '/tmp/imgs',
#     'original_file_name': '<PLATE>-<HHMMSSmmmm>-<SEQUENCE>-<CAMERA>-<PLATE_LEFT>-<PLATE_TOP>-<PLATE_RIGHT>-<PLATE_BOTTOM>.jpg',
#     'picture_generated_time':  datetime(),
#     'receive_time':  1638397123,
#     'inference_finish_time': 1638400000,
#     'img_url': '/tmp/img/xxx.jpg',
#     'img_with_bbox_url': '/tmp/img/xxx.jpg',
#     'license_plate': 'XXXX',
#     'license_plate_bbox': '(x1, y1, x2, y2)',
#     'camera_name': 'camera_name,
#     'sequence': 'sequence',
#     'violation': 'no mobile+safetybelt',
#     'score': 0.5,
#     'driver_bbox': str('[x1, y1, x2, y2]')
# }
#########################################################################
```

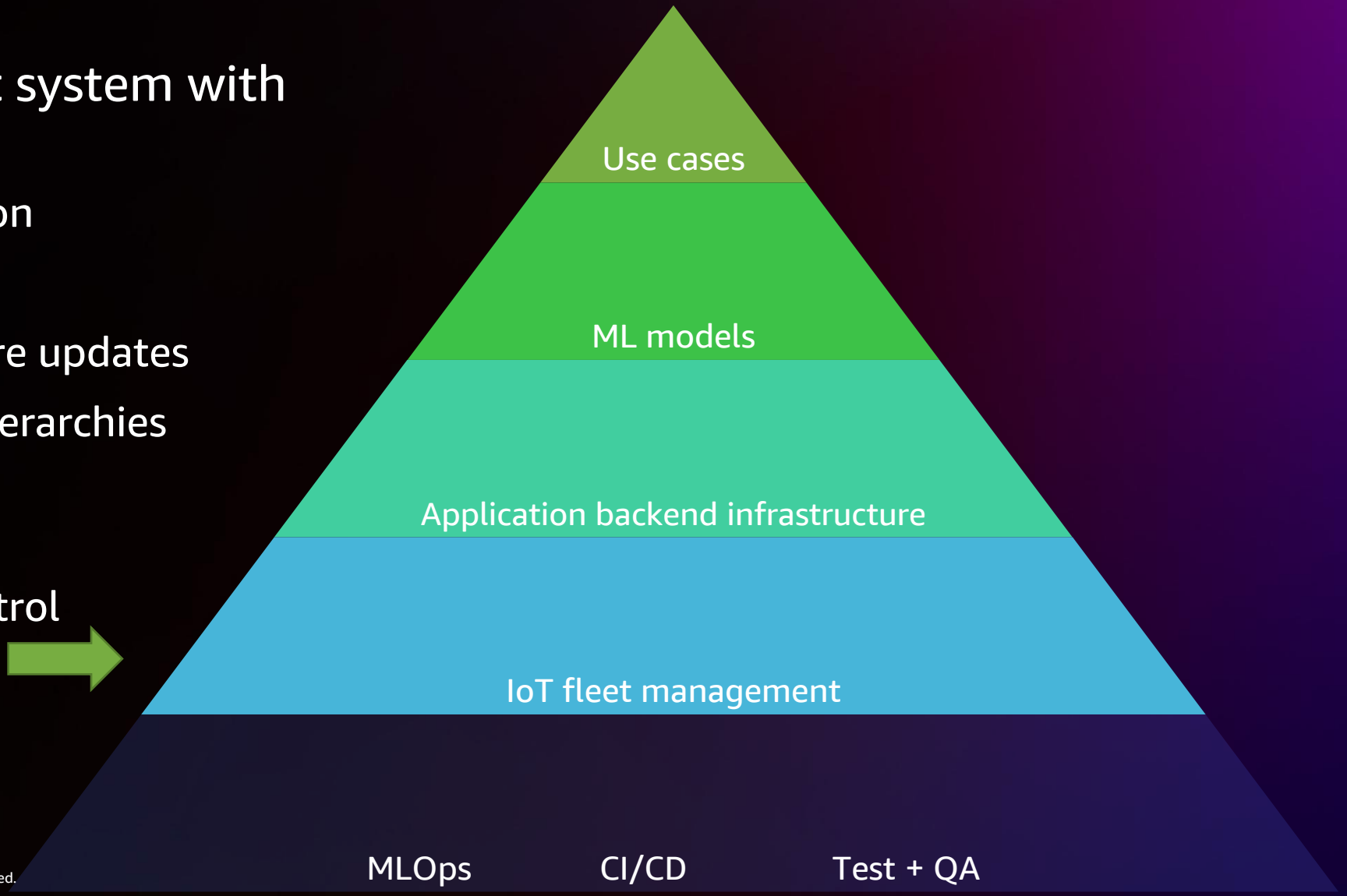


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Unpack a smart city ML solution

Automated management system with AWS IoT CDF

- Product template definition
- Provisioning
- Configuration and software updates
- Organizing devices into hierarchies
- Maintaining and updating device configuration
- Device command and control
- Device simulation
- Fleet simulation



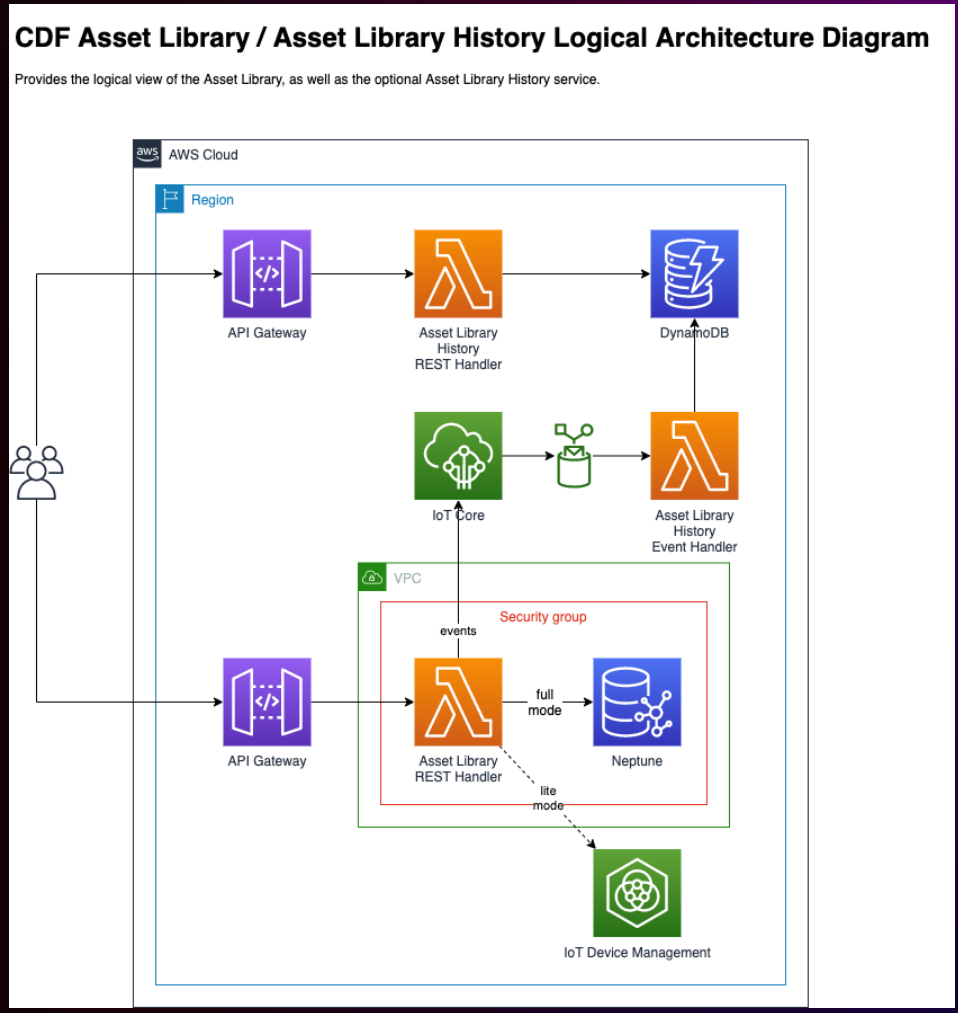
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AWS Connected Device Framework

The AWS Connected Device Framework (CDF) encompasses a set of modular micro-services (referred to simply as modules) to cater to connected devices in each of their lifecycle phases

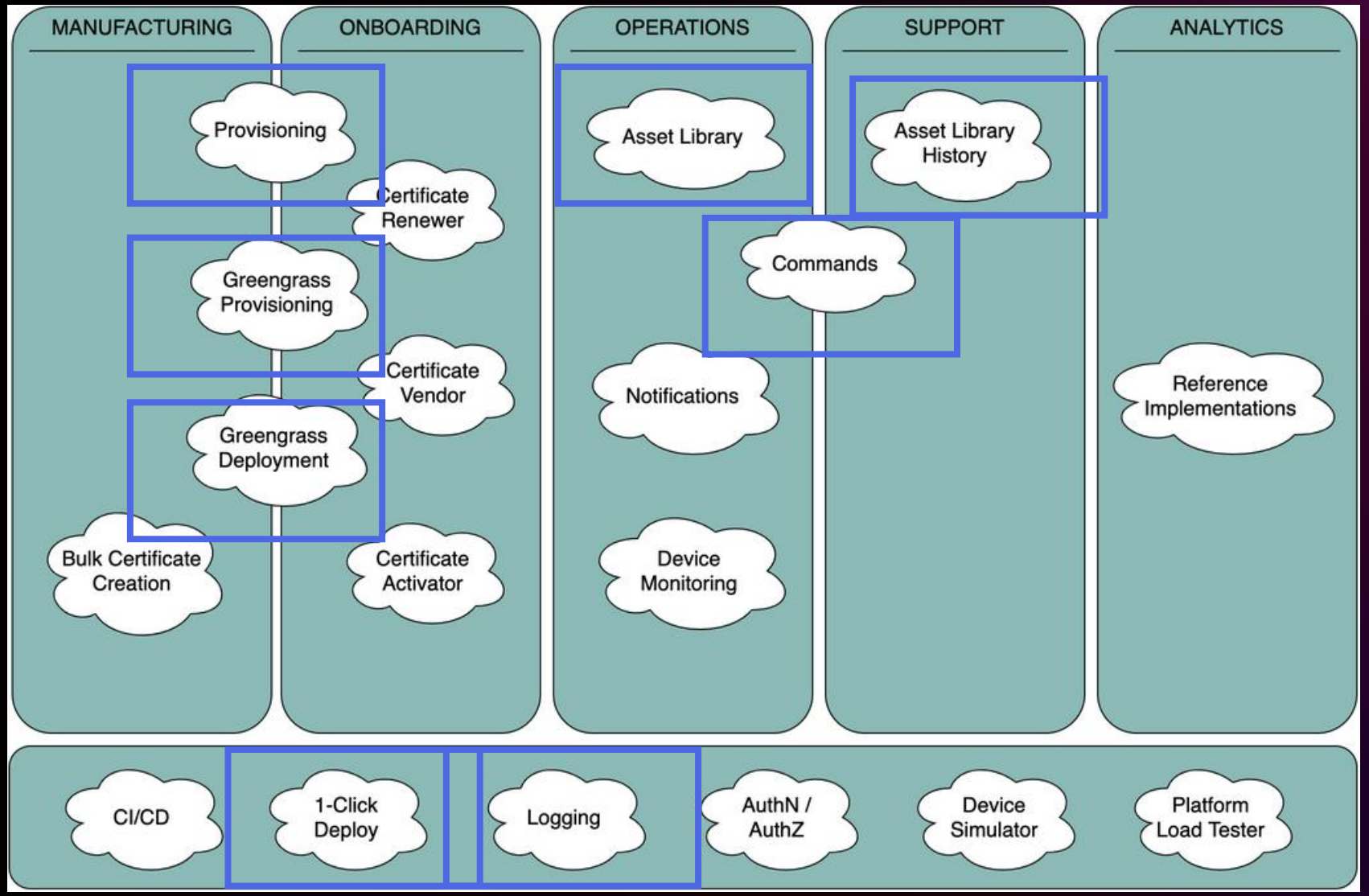
The framework is particularly well suited for enterprise use cases which require product definition, onboarding and managing a diverse ecosystem of connected devices – please follow the link below for more information on CDF

https://github.com/aws/aws-connected-device-framework



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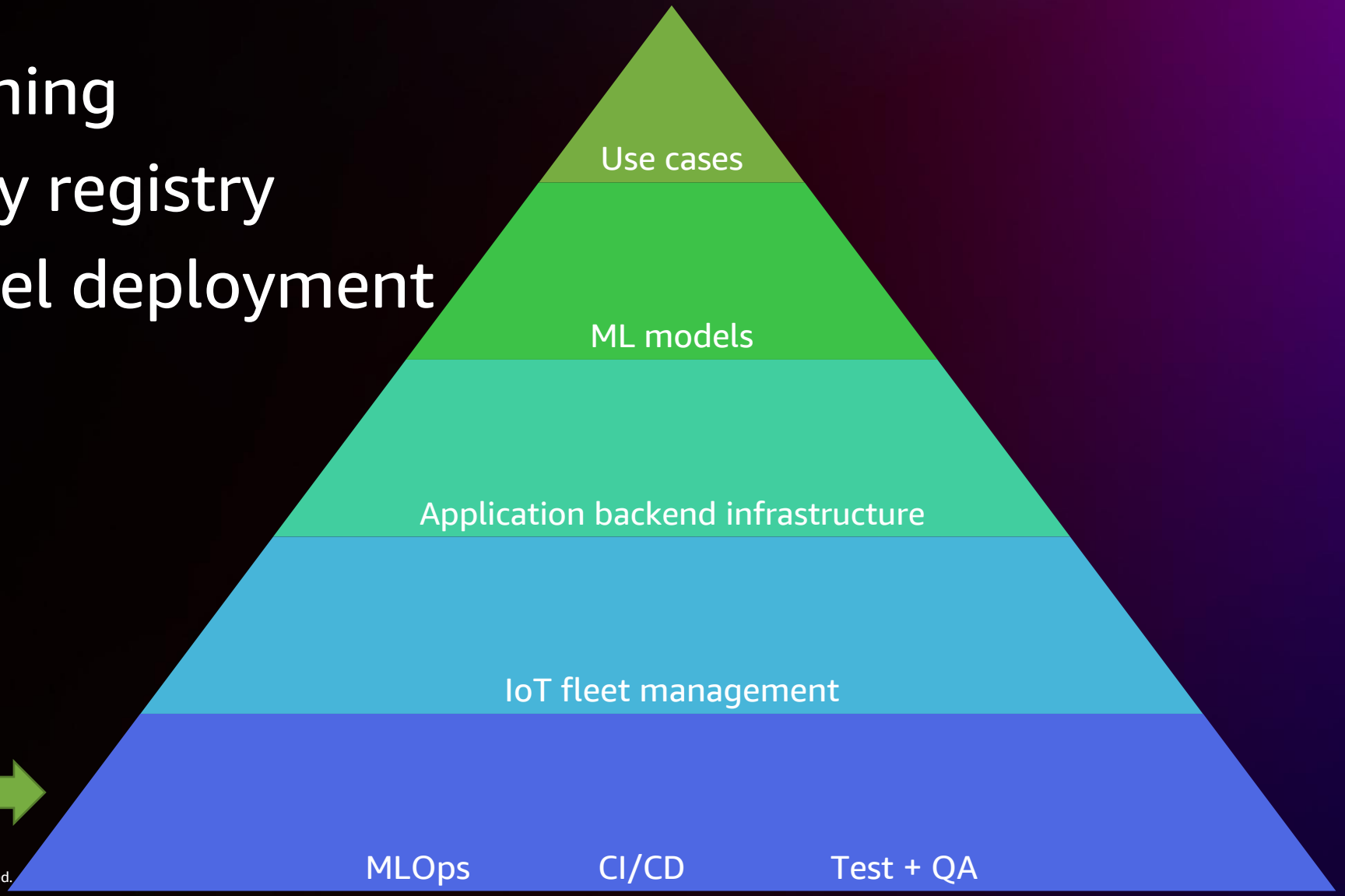
AWS Connected Device Framework



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Unpack a smart city ML solution

- ML model retraining
- ML model history registry
- Automated model deployment
- DevOps tools
- QA system tests



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MLOps and CI/CD

Why MLOps?

- ML model training has lots of steps and configurations
- ML models drift, need to retrain frequently
- Model version control based on newly trained model evaluation
- Automate data preprocessing from Ground Truth to training pipeline

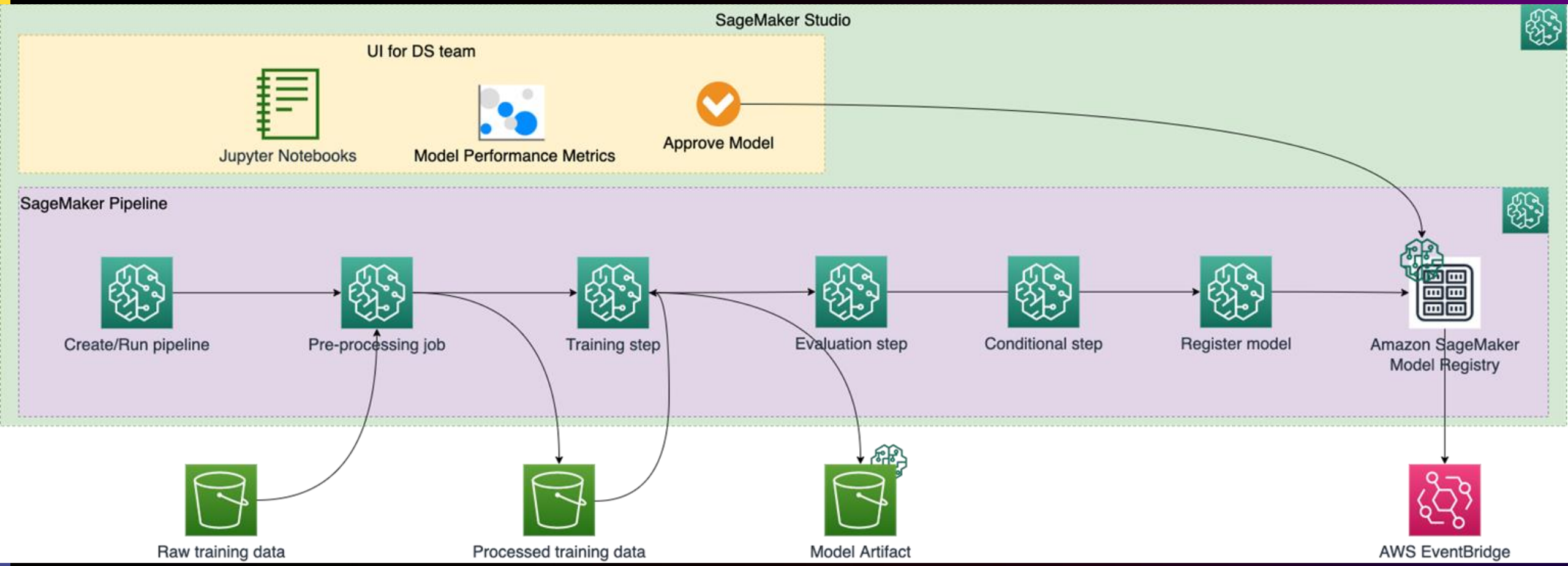
Why CI/CD?

- Automated retraining and model deployment upon code update
- Multiaccount handling (dev → QA/test → prod)
- Manual approval step to ensure security and reliability

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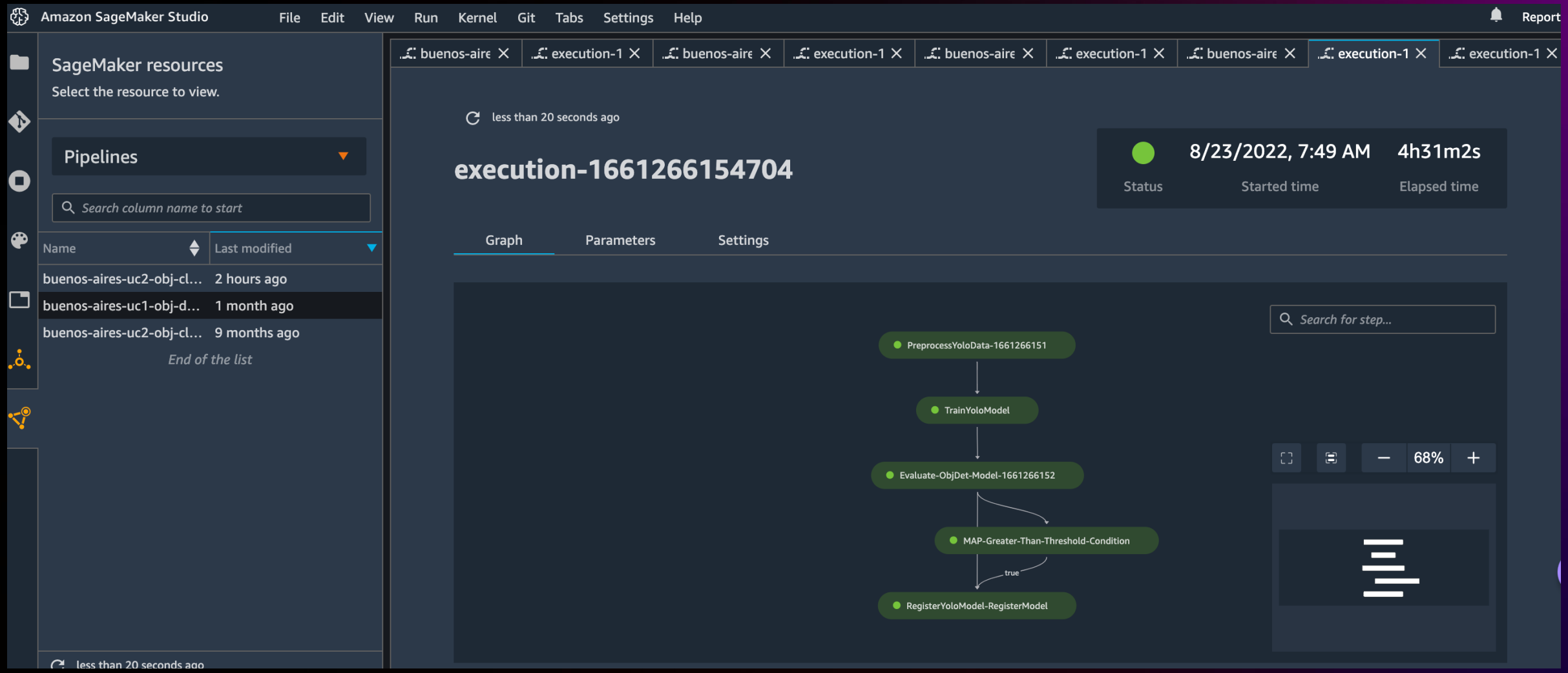
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ML model building pipeline



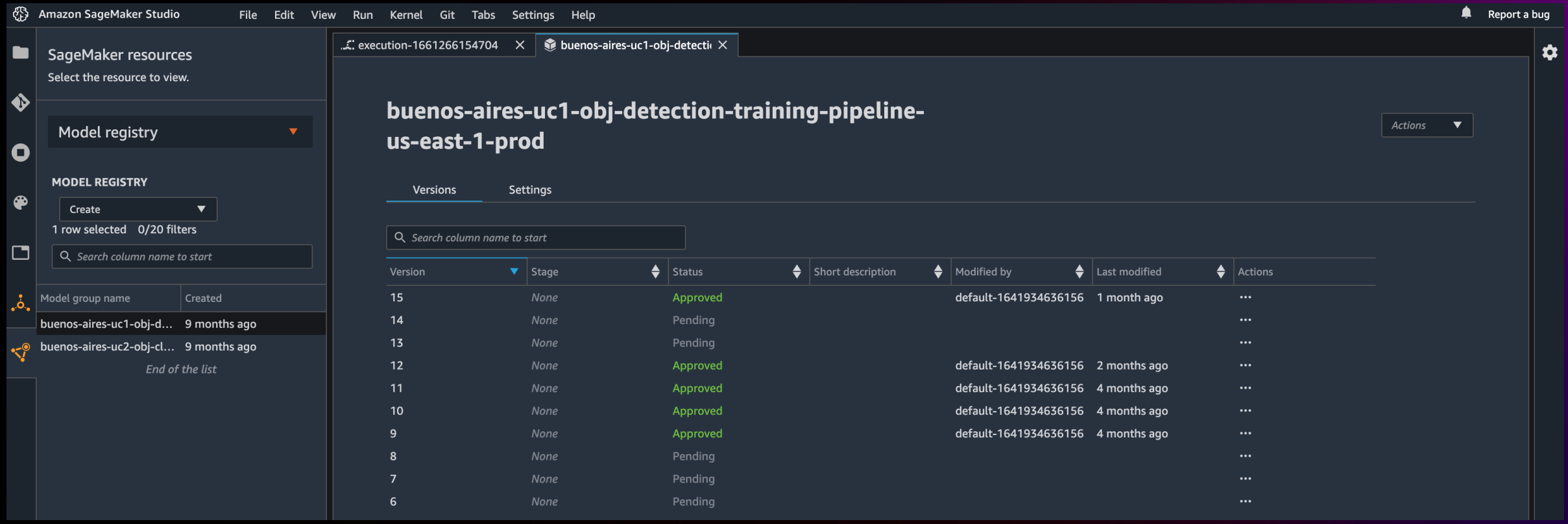
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ML model building pipeline



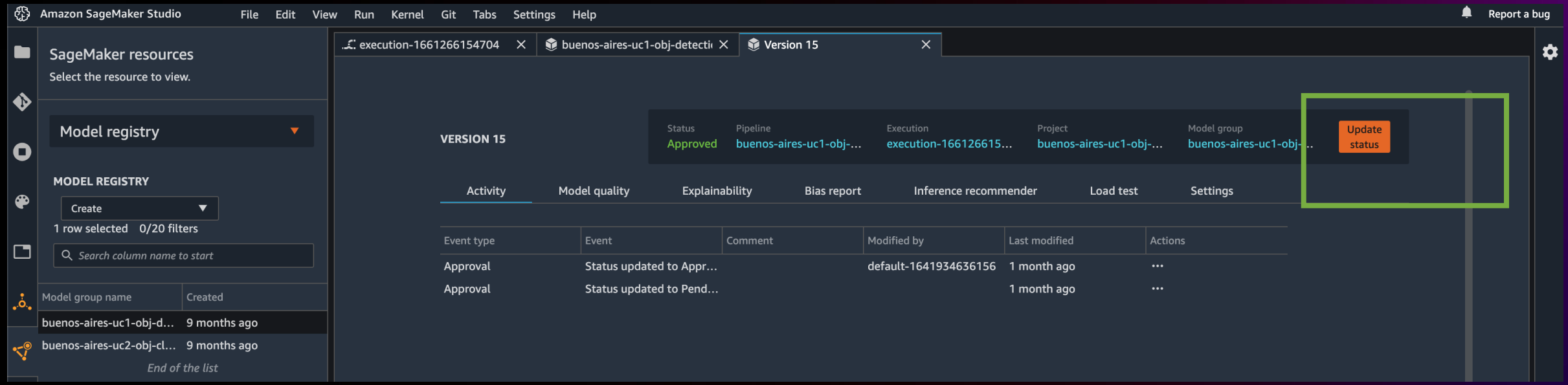
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ML model building pipeline



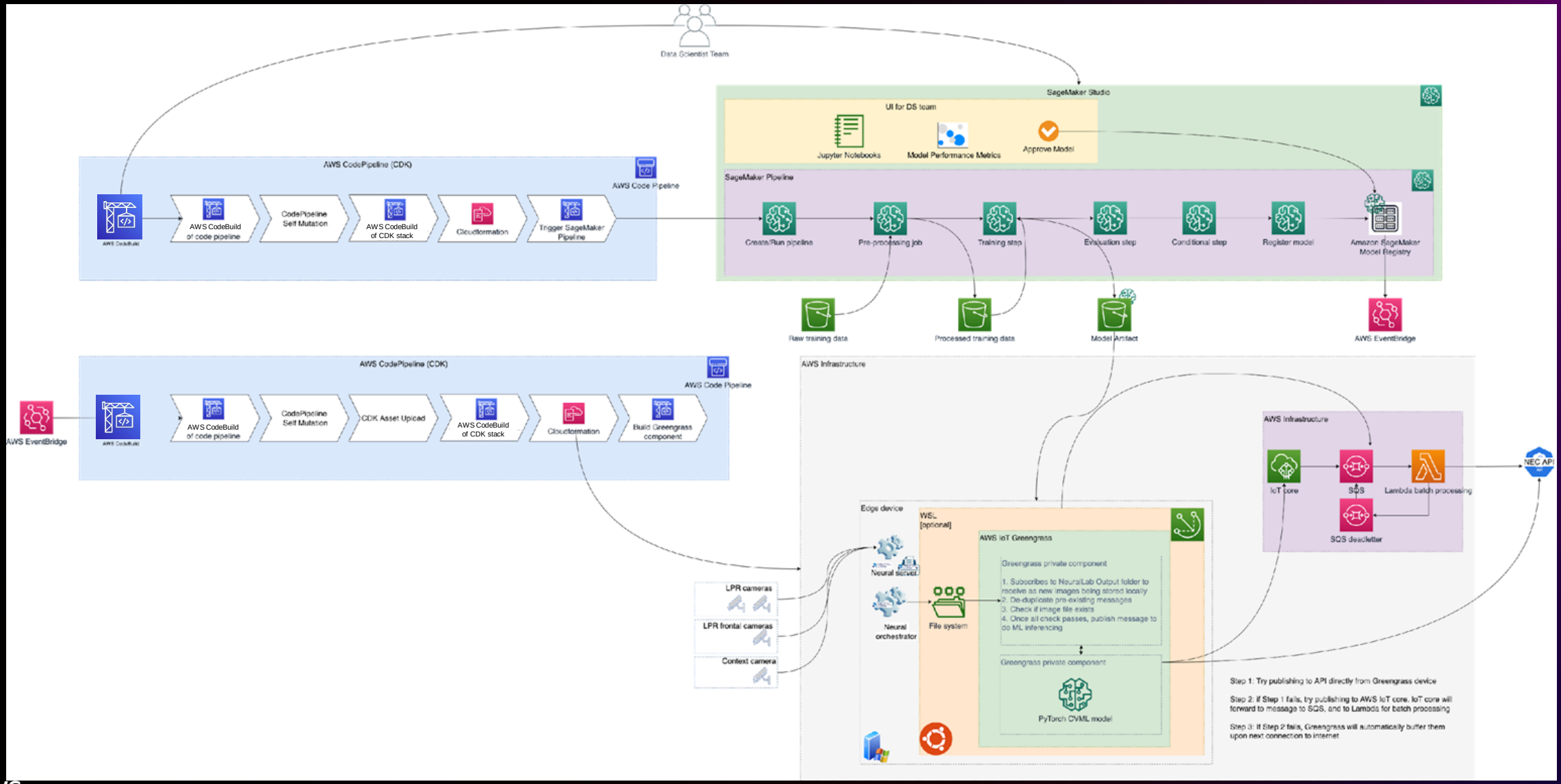
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ML model building pipeline



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MLOps automated training pipeline



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