MathWorks
AUTOMOTIVE CONFERENCE 2023
Europe

Demystifying DevOps: A Cloud Workflow for Fleet Analytics with Machine Learning

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MathWorks

Key Takeaways

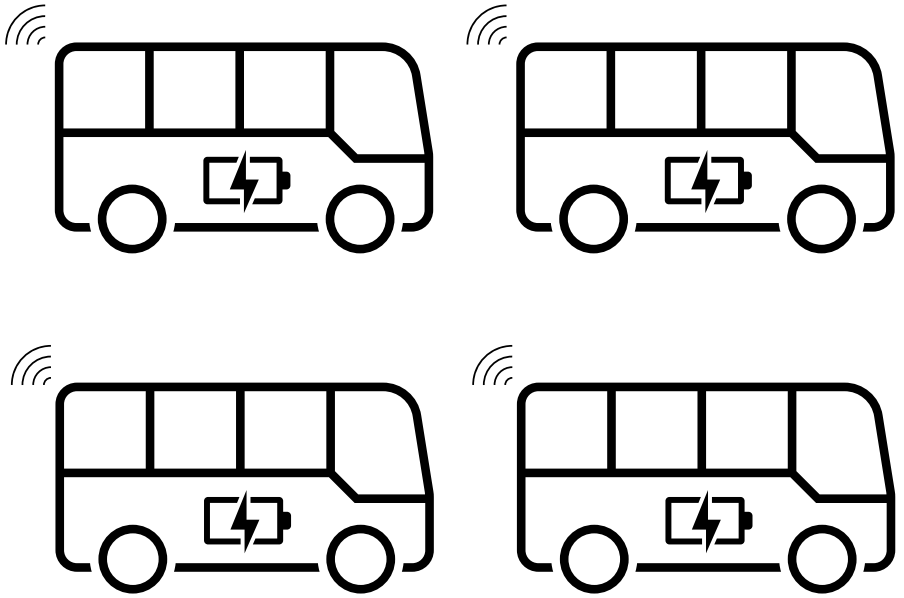
Incorporate familiar MATLAB & Simulink capabilities in a DevOps workflow

Integrate with production systems to transition from desktop to cloud

CI/CD

Automatically test, build, and deploy MATLAB code and Simulink models

Example use case: Predicting Battery State-of-Health



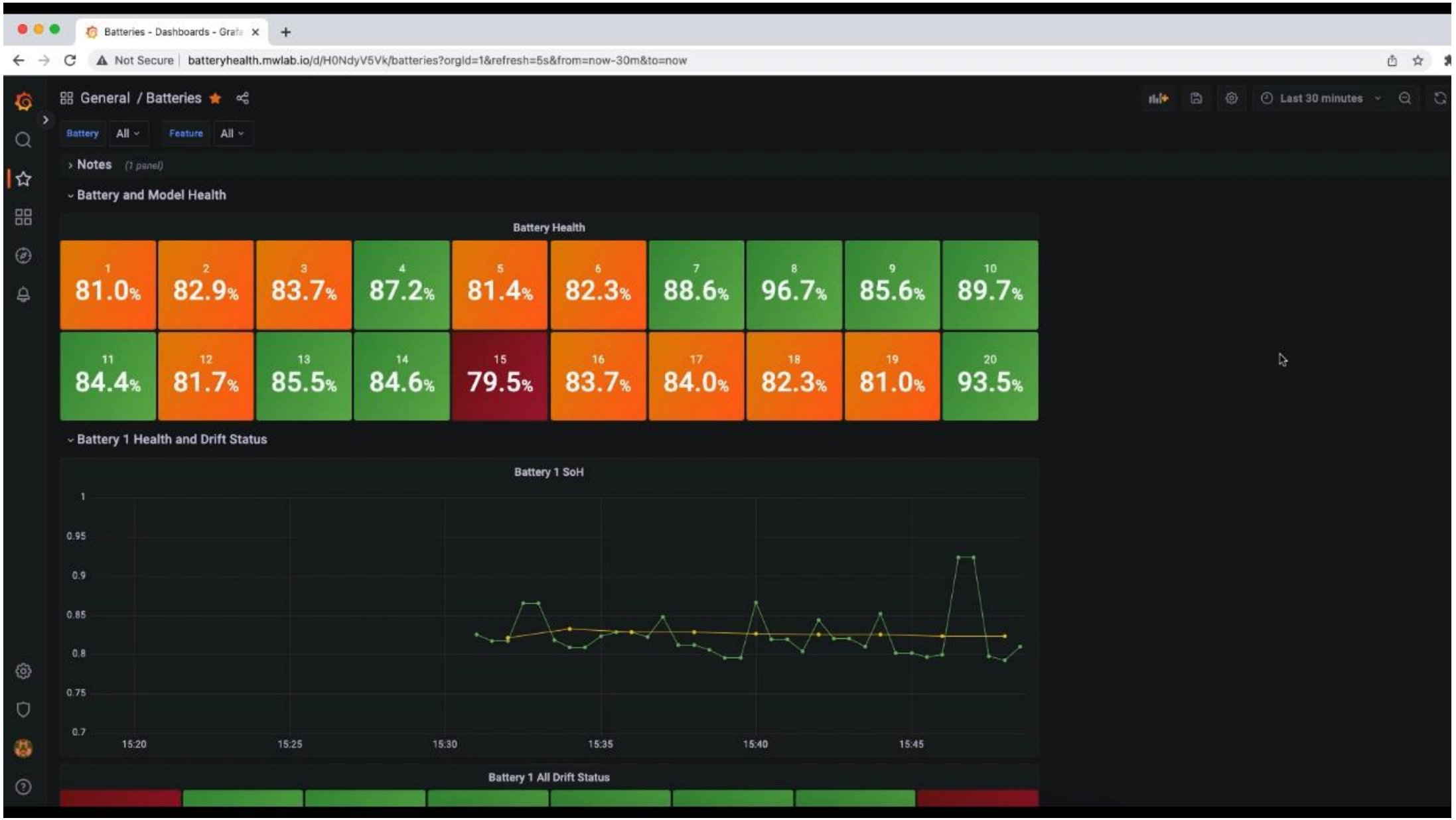
- Fleet of electric buses
- Maintenance is expensive. **Could we do a better job predicting when batteries need replacing?**
- Started gathering telemetry data on batteries

Variables – observations

observations

1800x7 timetable

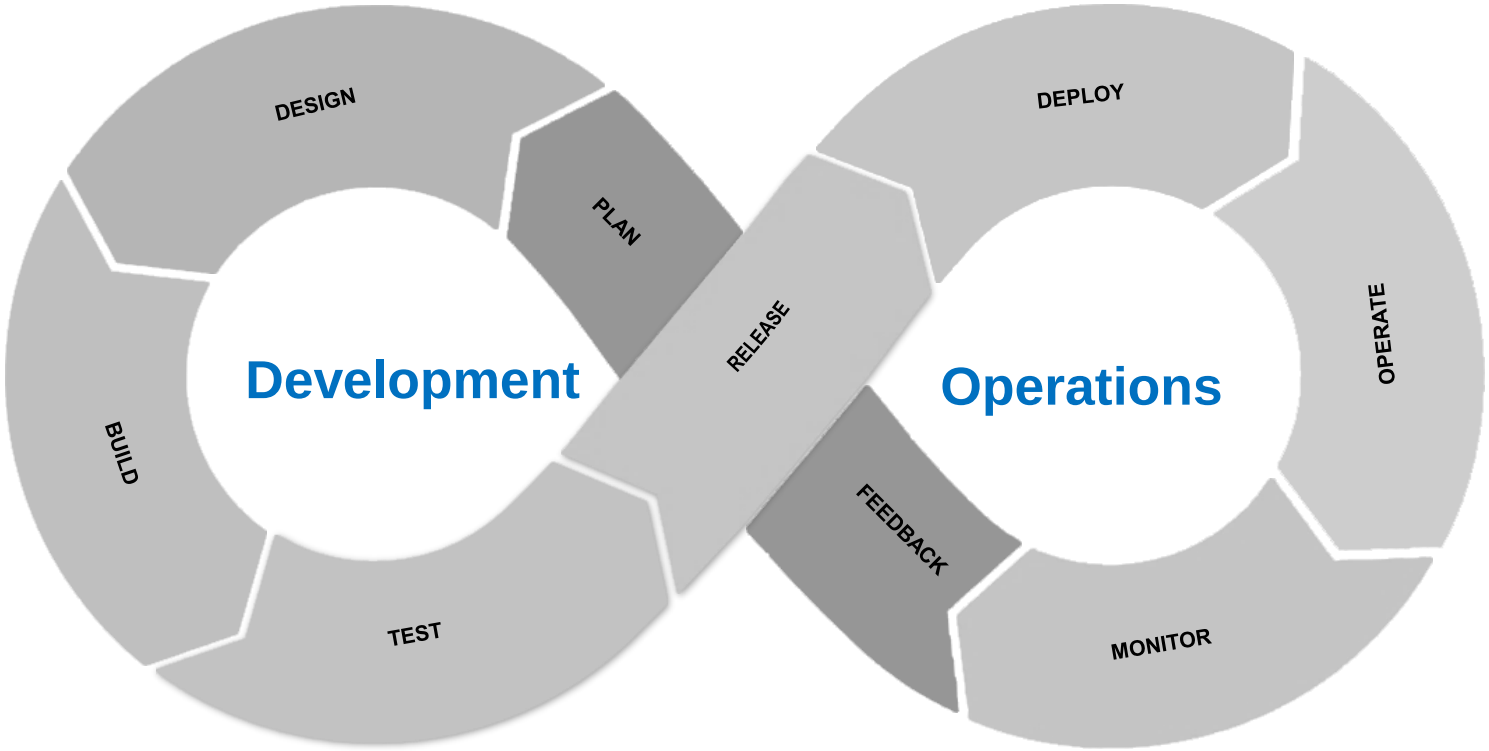
	timestamp	1 Current	2 Voltage	3 Temperature1	4 Temperature2	5 SoC_B1	6 SoC_B2	7 BatteryID
1	01-Nov-2021 00:...	2.6869	7.4436	333.1463	332.7619	0.4995	0.4995	1
2	01-Nov-2021 00:...	2.6872	7.4426	333.1317	332.3924	0.4990	0.4990	1
3	01-Nov-2021 00:...	2.6876	7.4417	333.1073	332.0405	0.4985	0.4985	1
4	01-Nov-2021 00:...	2.6879	7.4408	333.0740	331.7048	0.4980	0.4980	1
5	01-Nov-2021 00:...	2.6882	7.4399	333.0327	331.3844	0.4975	0.4975	1
6	01-Nov-2021 00:...	2.6885	7.4390	332.9843	331.0783	0.4970	0.4970	1
7	01-Nov-2021 00:...	2.6889	7.4381	332.9295	330.7857	0.4965	0.4965	1


Batteries - Dashboards - Grafa
Not Secure
batteryhealth.mwlab.io/d/H0NdyV5Vk/batteries?orgId=1&refresh=5s&from=now-30m&to=now
General / Batteries
Last 30 minutes
Battery
All
Feature
All
Notes (1 panel)
Battery and Model Health
Battery Health
1 81.0%
2 82.9%
3 83.7%
4 87.2%
5 81.4%
6 82.3%
7 88.6%
8 96.7%
9 85.6%
10 89.7%
11 84.4%
12 81.7%
13 85.5%
14 84.6%
15 79.5%
16 83.7%
17 84.0%
18 82.3%
19 81.0%
20 93.5%
Battery 1 Health and Drift Status
Battery 1 SoH
1
0.95
0.9
0.85
0.8
0.75
0.7
15:20
15:25
15:30
15:35
15:40
15:45
Battery 1 All Drift Status

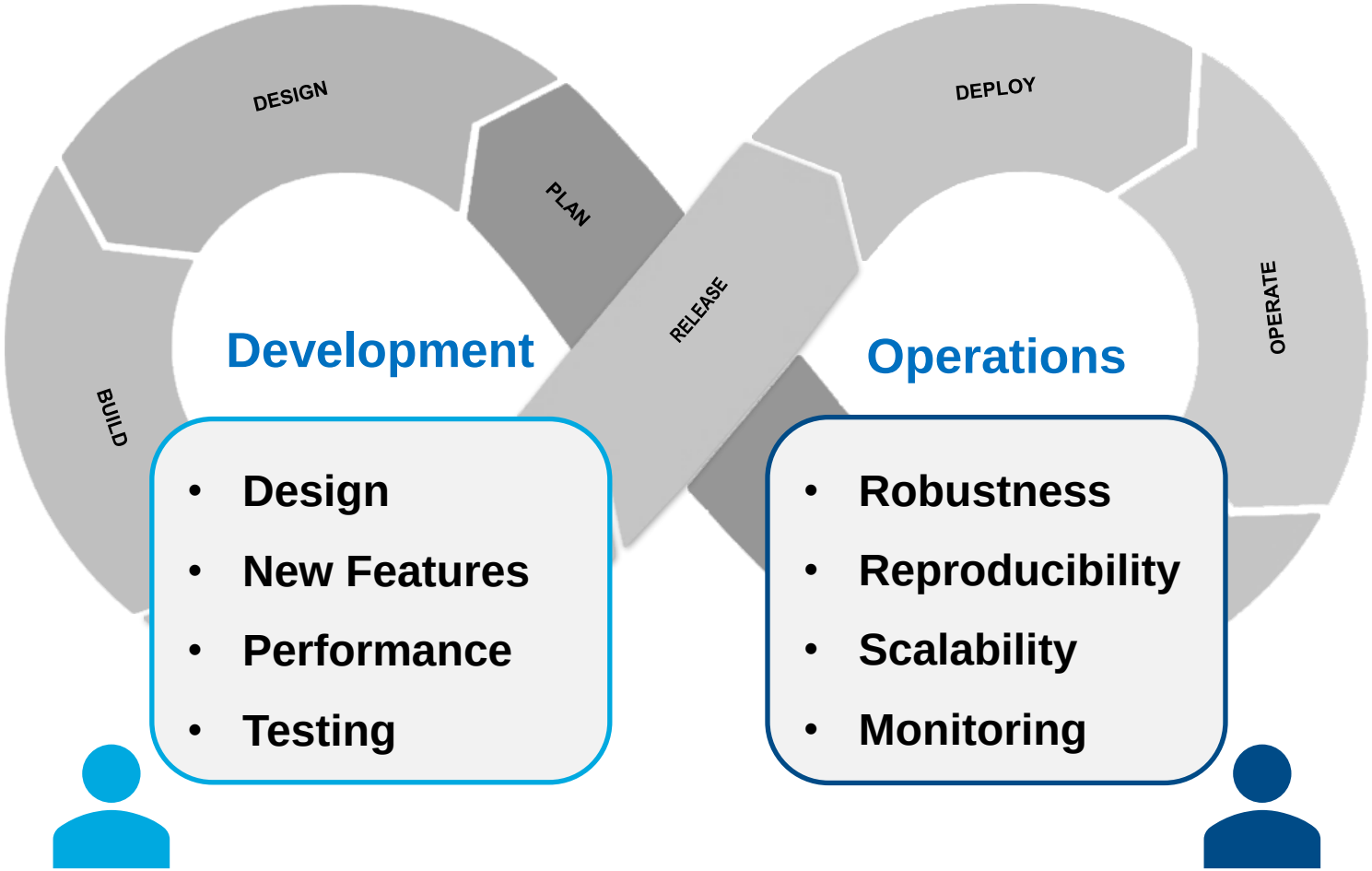
Apply DevOps practices and make your lives easier

- Improve **collaboration** through shared responsibility
- Improve **flow** through high degree of **automation**
  Engineers keep engineering
- Get early **feedback** and **resolve issues faster** through continuous system monitoring

DevOps: Develop and Operate Production Software



DevOps: Develop and Operate Production Software



DevOps Permeates Entire Model Lifecycle

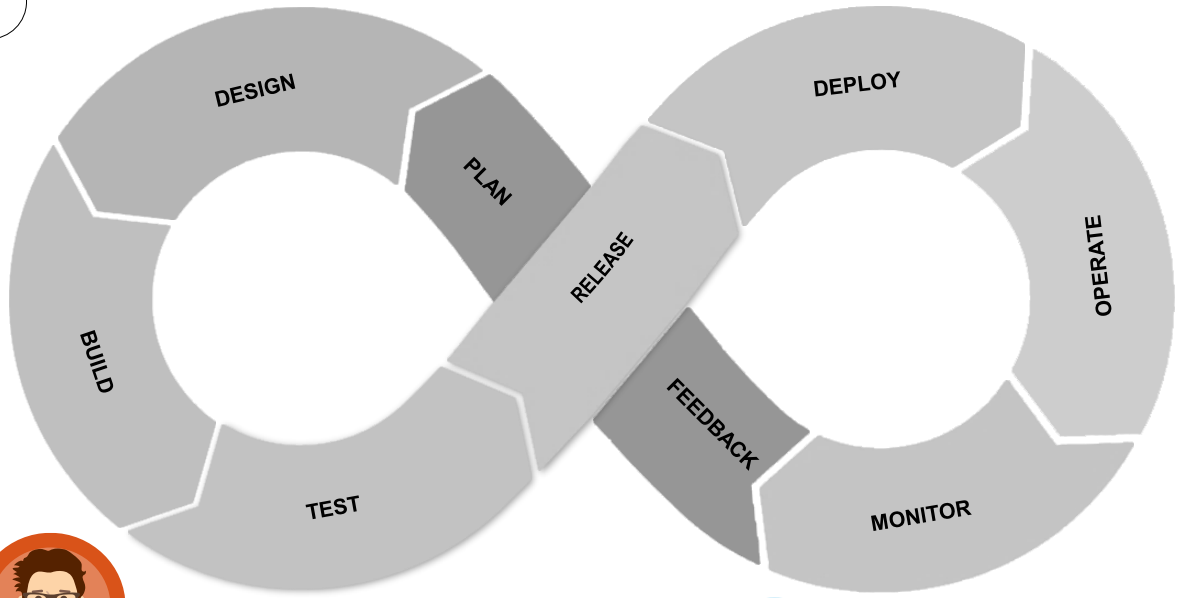
Physical models that drive the deployed system


Domain Engineer


Product Manager


IT Infrastructure Engineer


Data Scientist



Reproducible and maintainable **IT systems, infrastructure as code**


Data Engineer

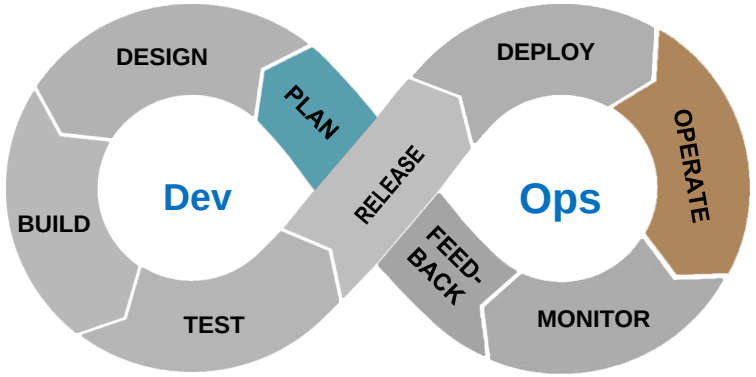

Business Analyst

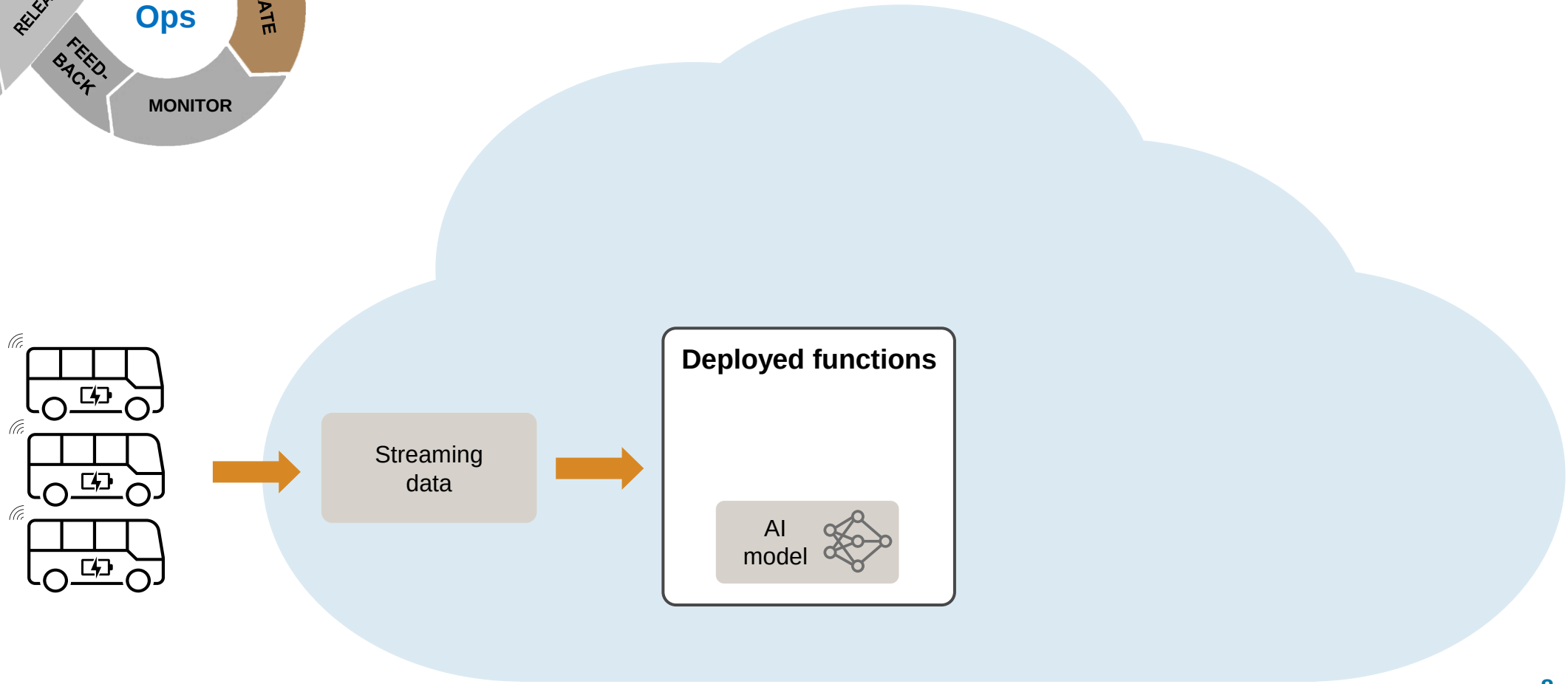

System Integrator

Authoring

Running the Workflow in Other Execution Environments

System overview





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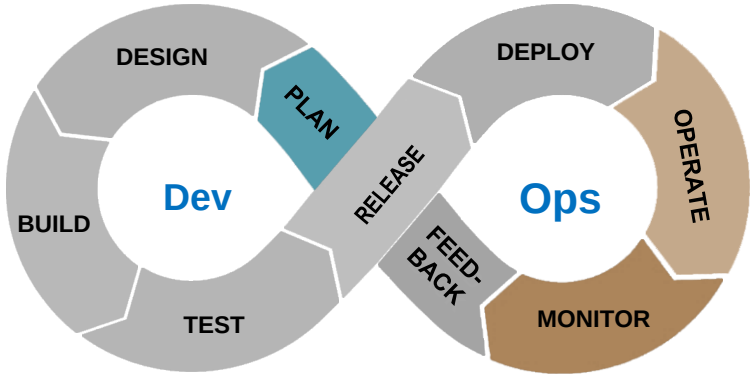

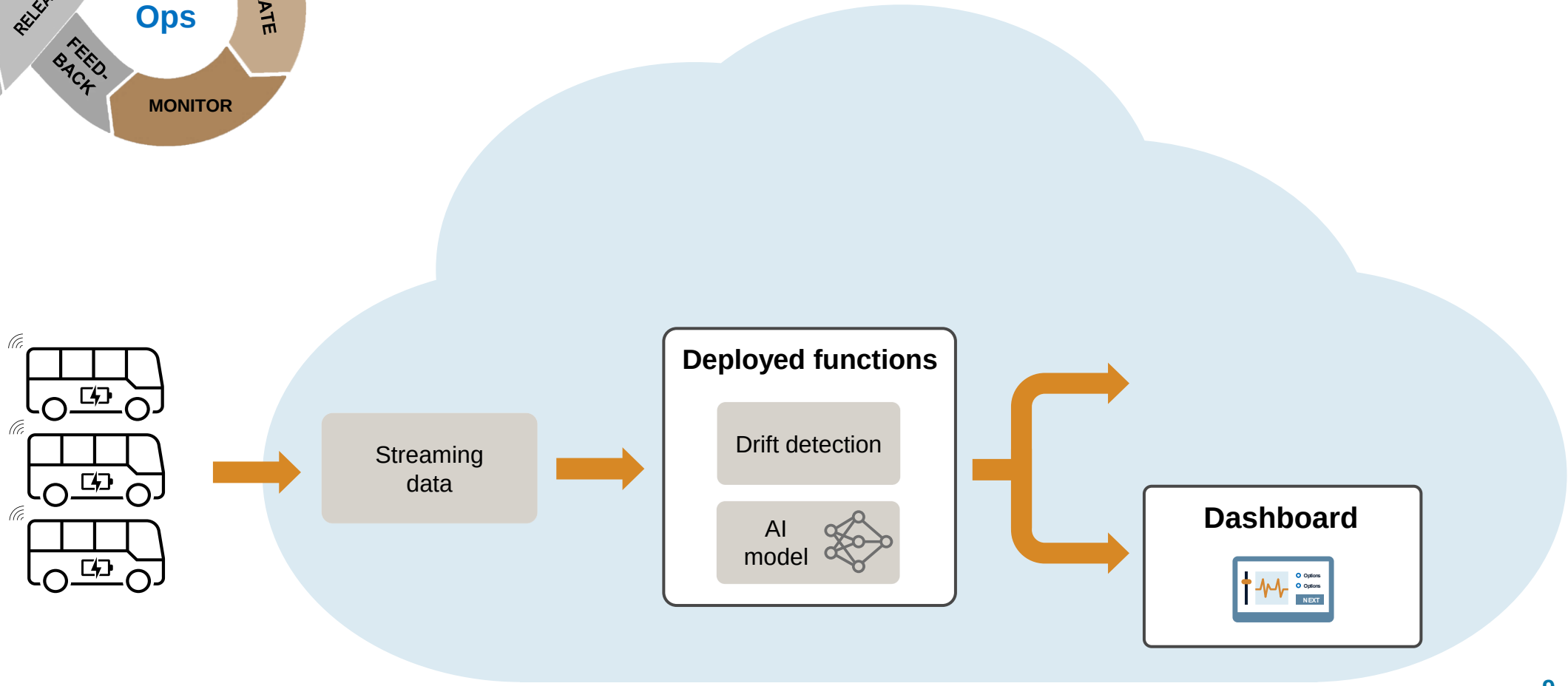

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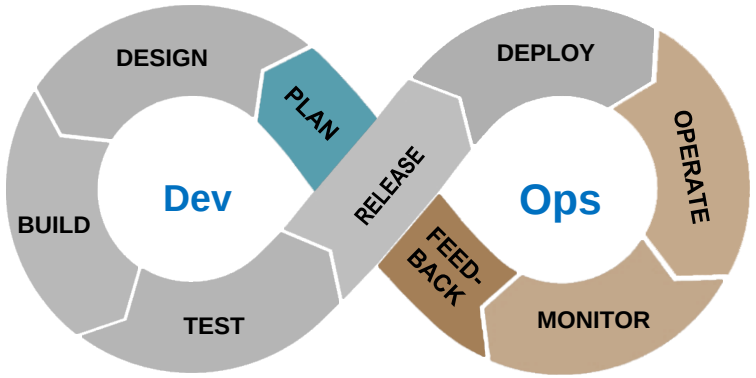
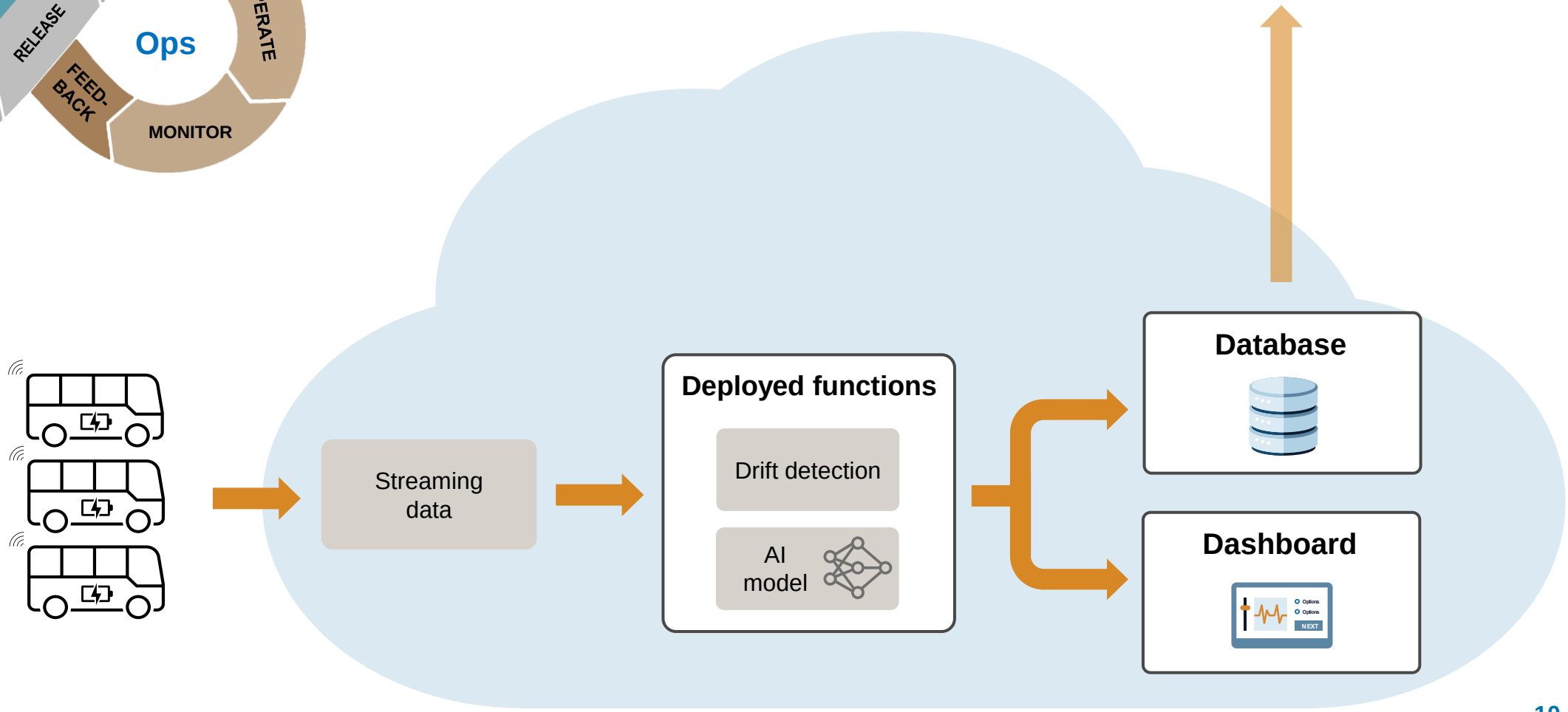
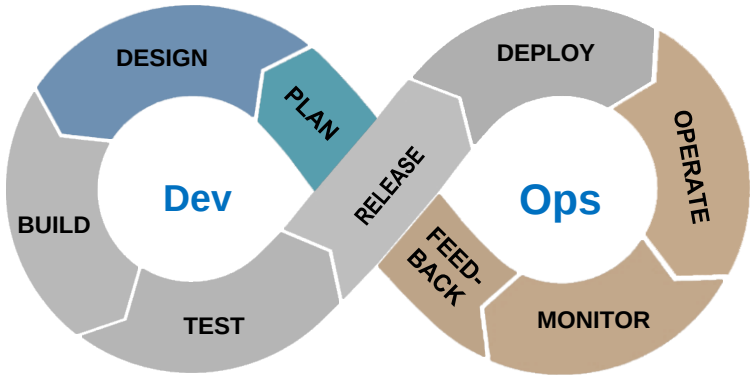


MATLAB Developer

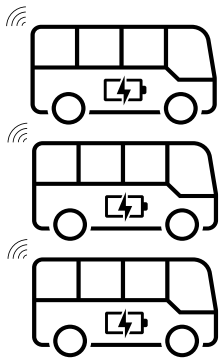


System overview



AI model

MATLAB Developer



Streaming data

Deployed functions

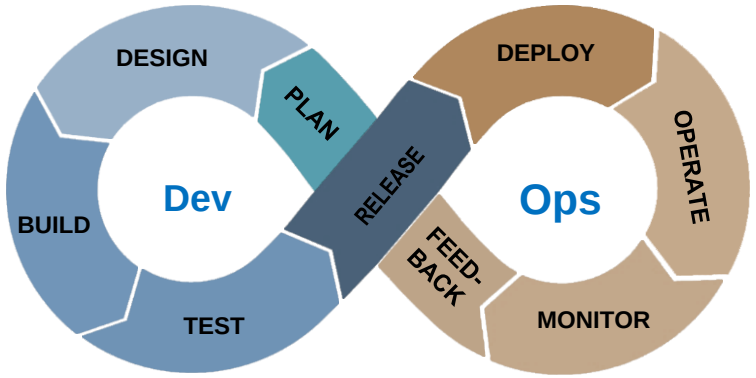
Drift detection

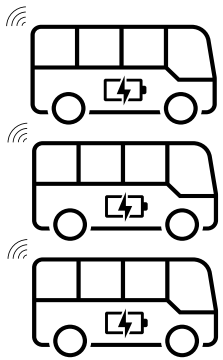
AI model

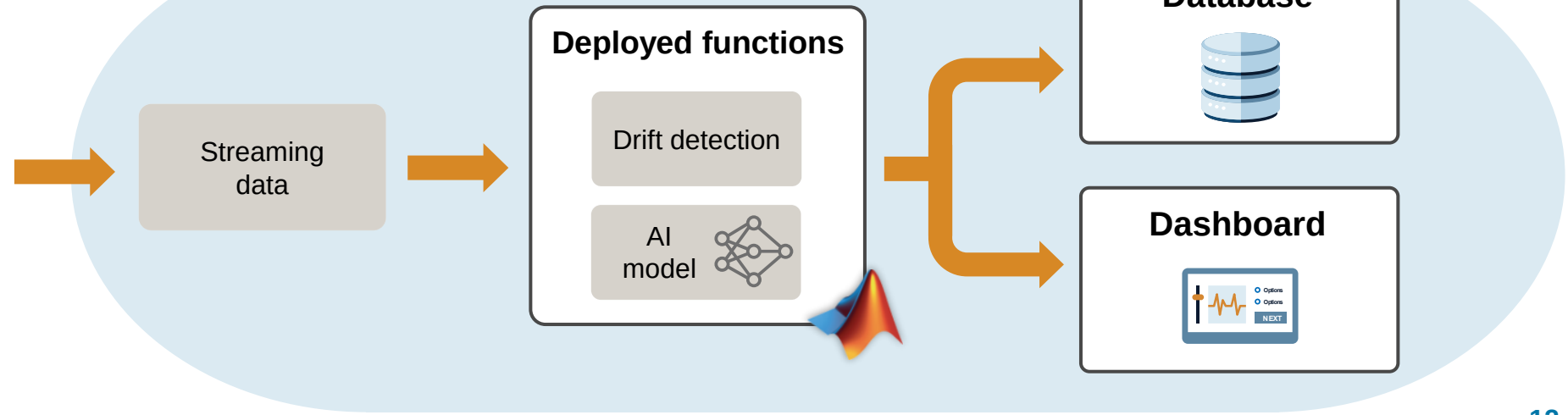
Database

Dashboard

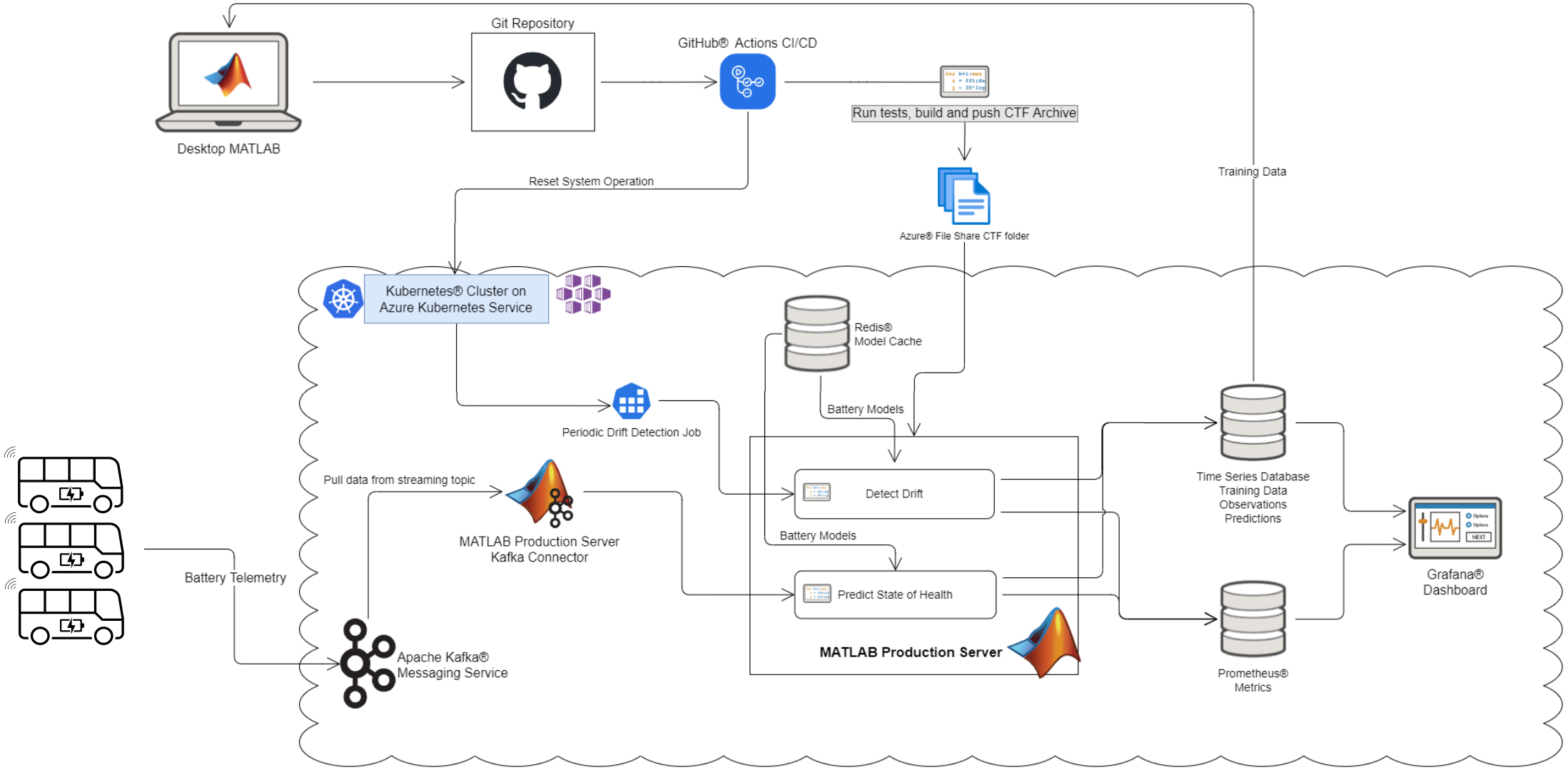
System overview







A scalable production system running on the cloud, using industry standard tools



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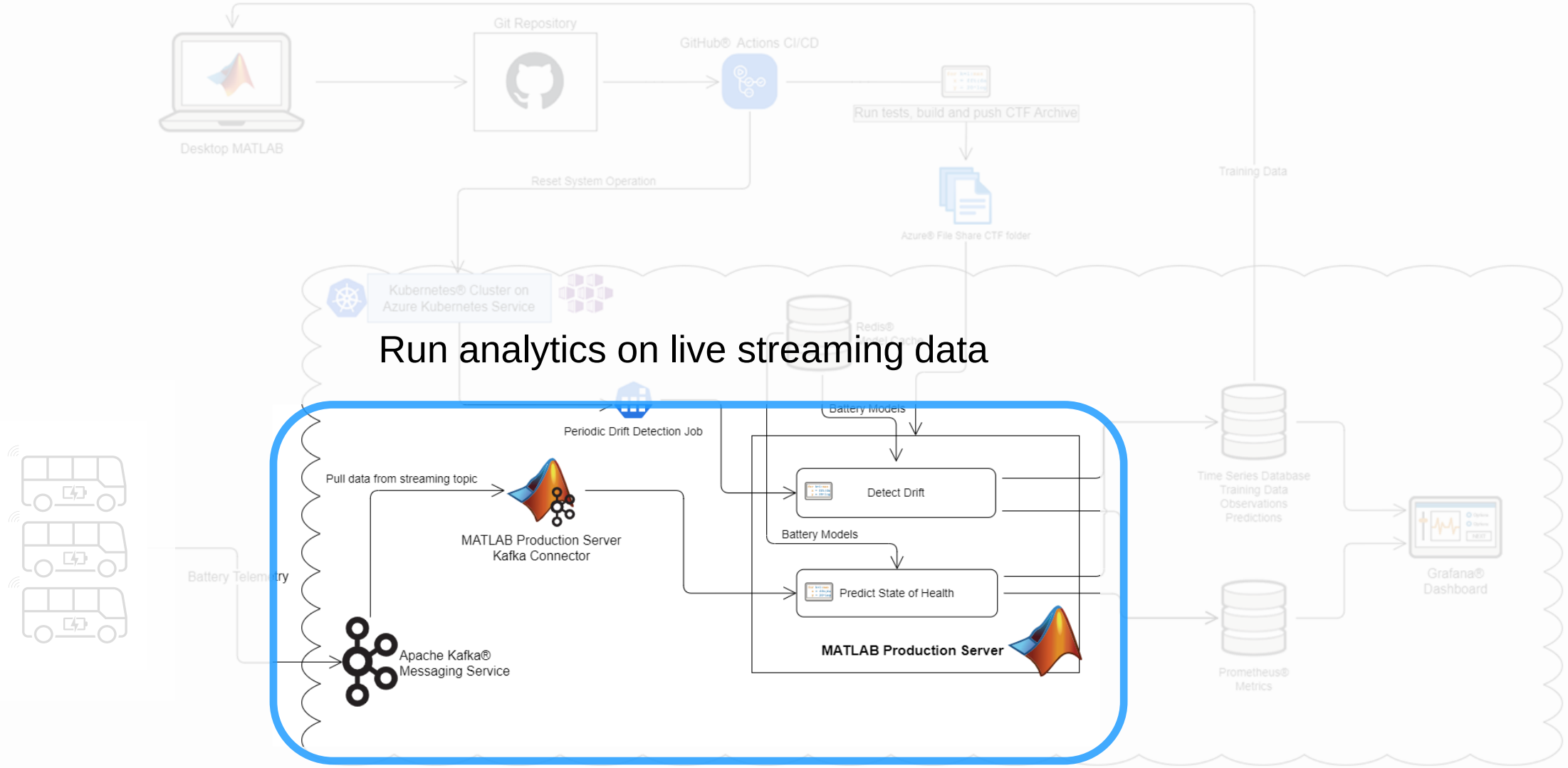
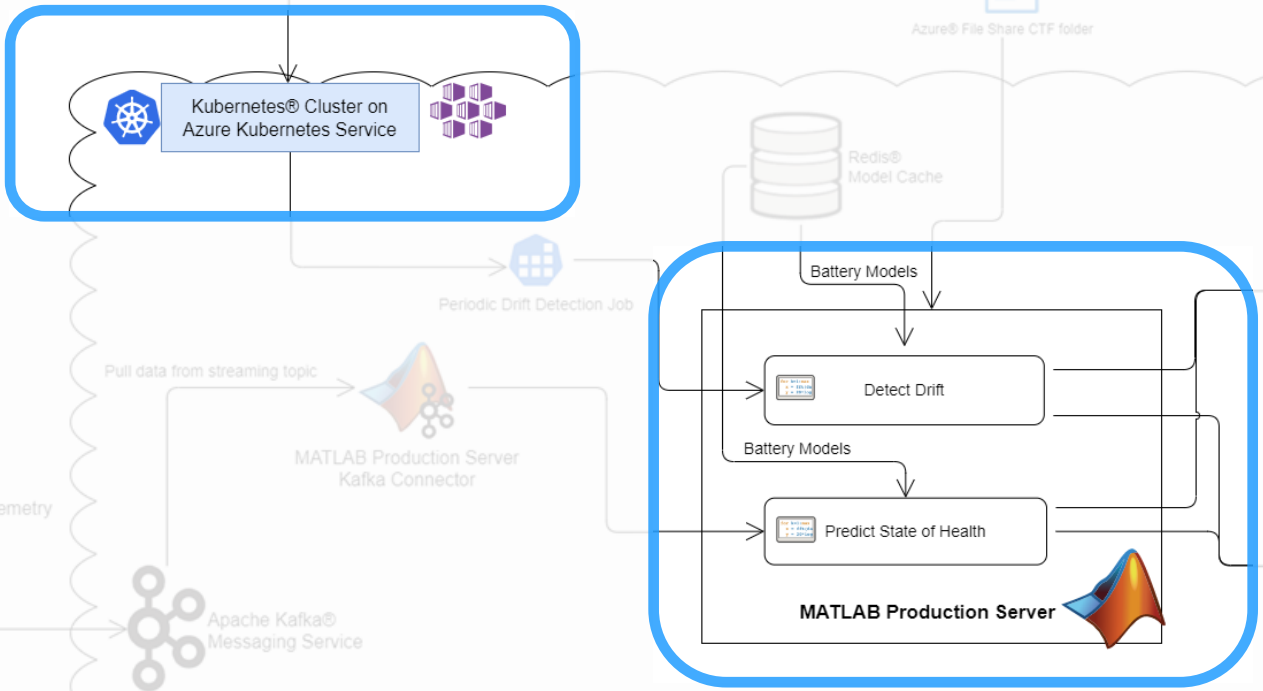


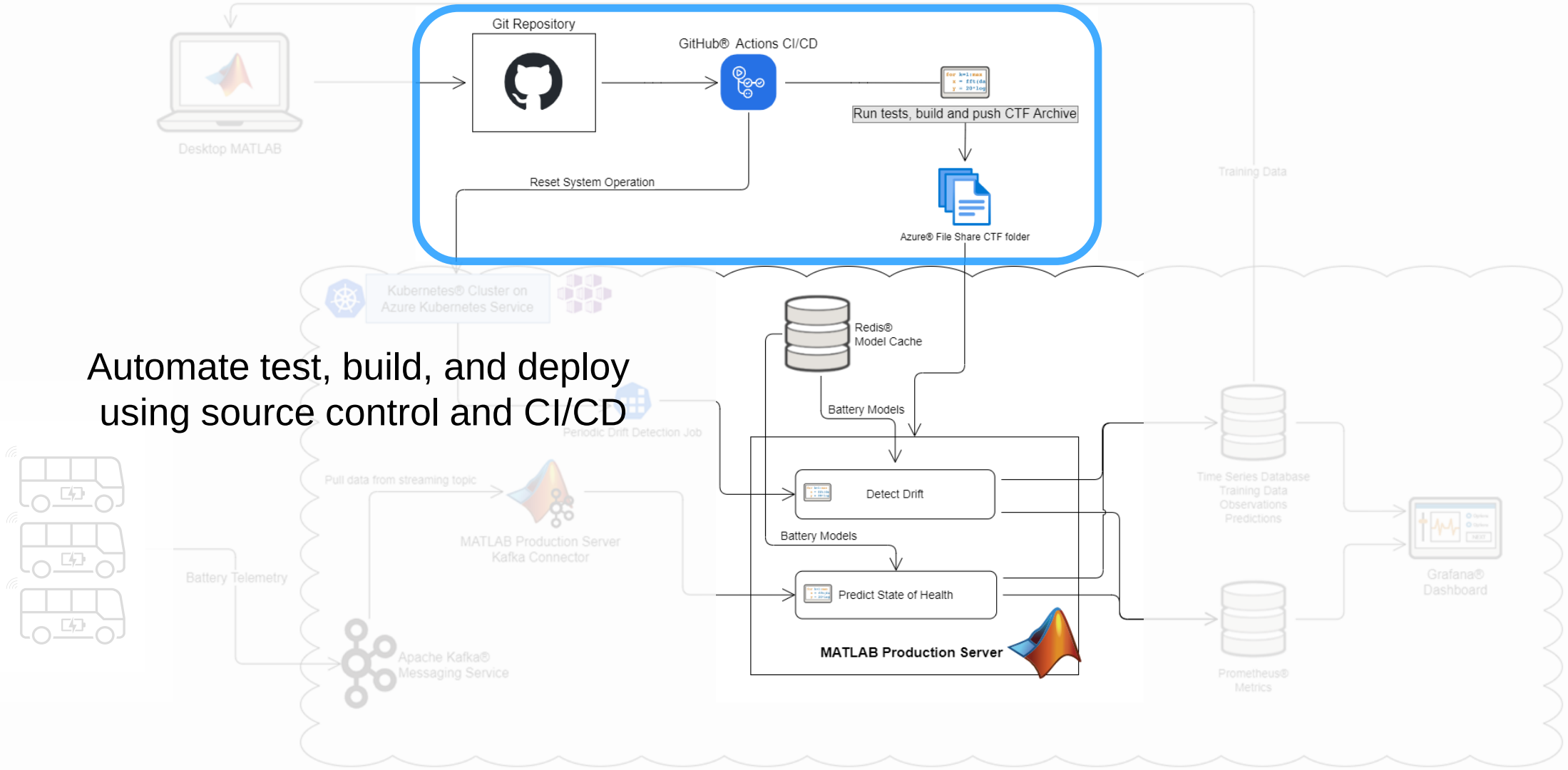
A scalable production system running on the cloud, using industry standard tools

Deploy MATLAB Production Server in containers on cloud infrastructure



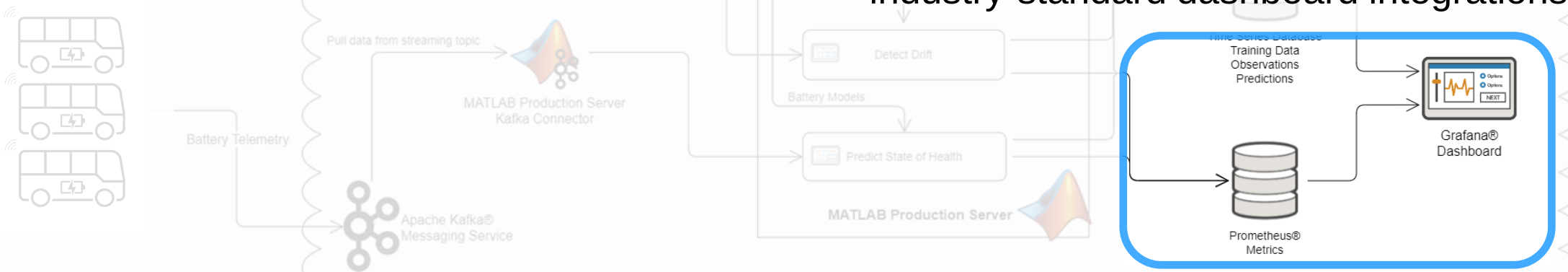
A scalable production system running on the cloud, using industry standard tools

Automate test, build, and deploy using source control and CI/CD



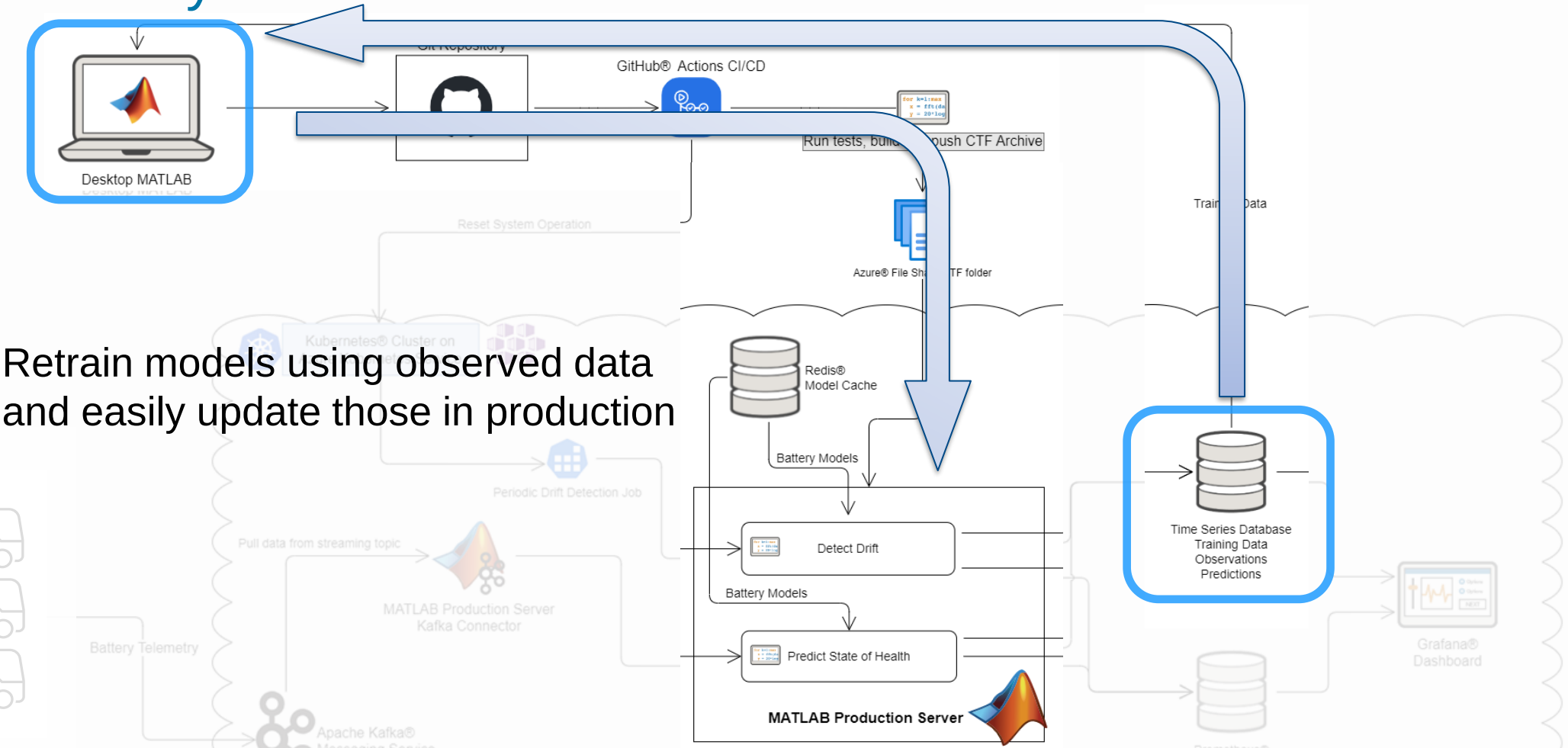
A scalable production system running on the cloud, using industry standard tools

Expose valuable metrics to business stakeholders using industry-standard dashboard integrations

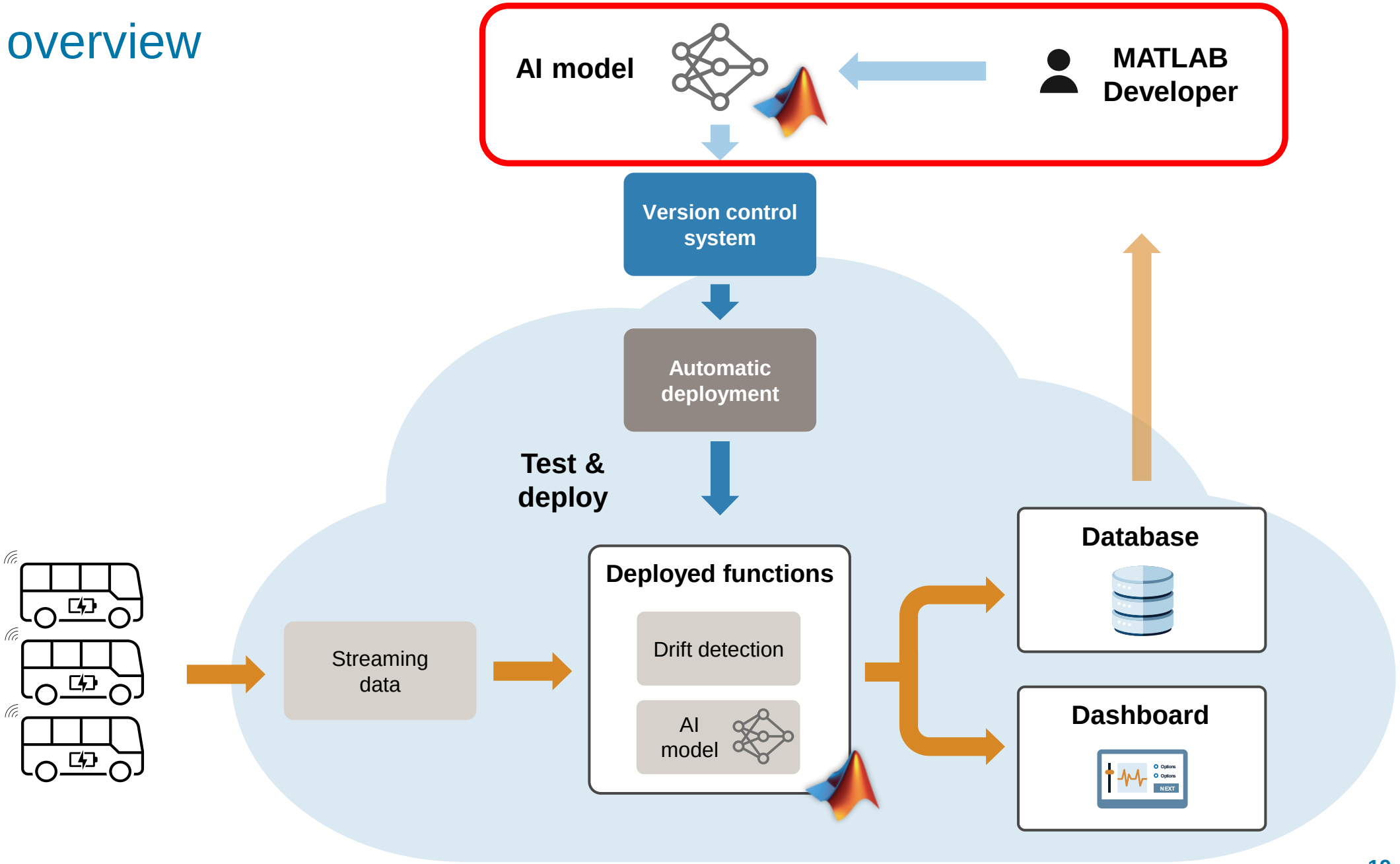


A scalable production system running on the cloud, using industry standard tools

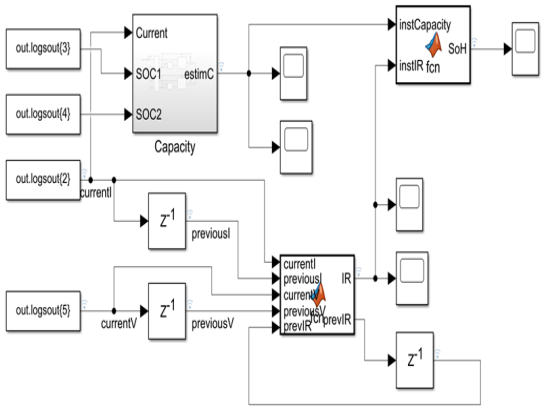
Retrain models using observed data and easily update those in production

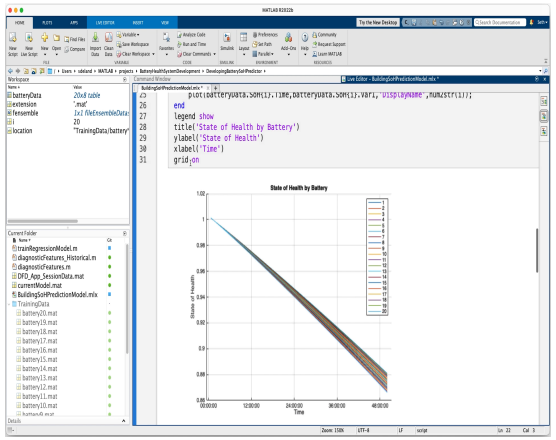


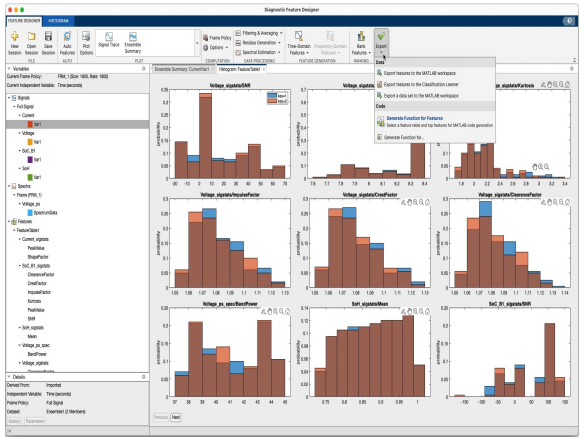
System overview

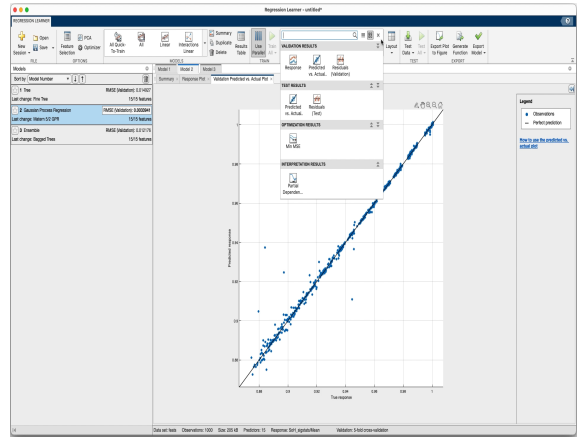


Low-code machine learning workflow



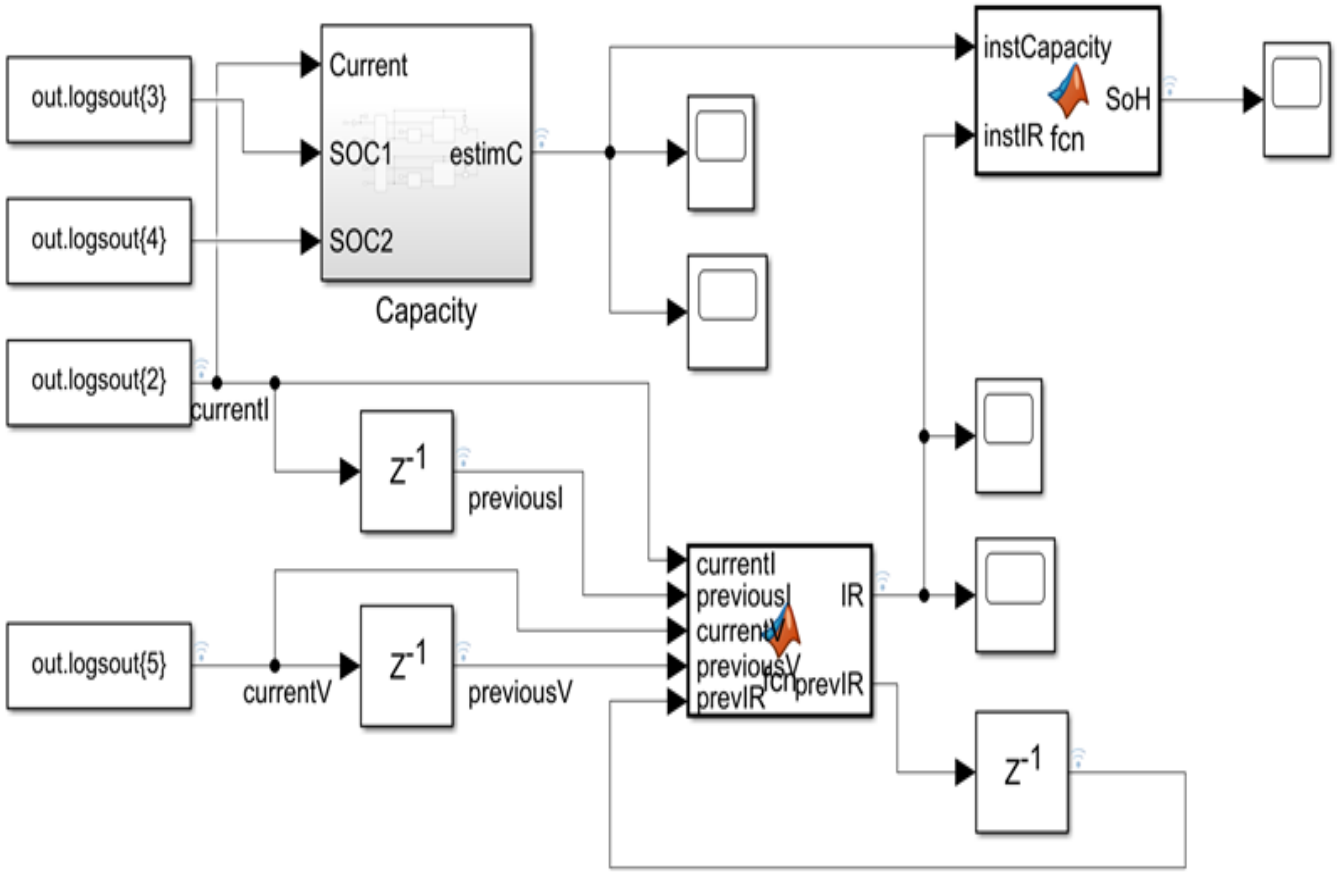






Data labeling → **Data Exploration** → **Feature Extraction** → **Machine Learning**

First-principles-model used for labeling data



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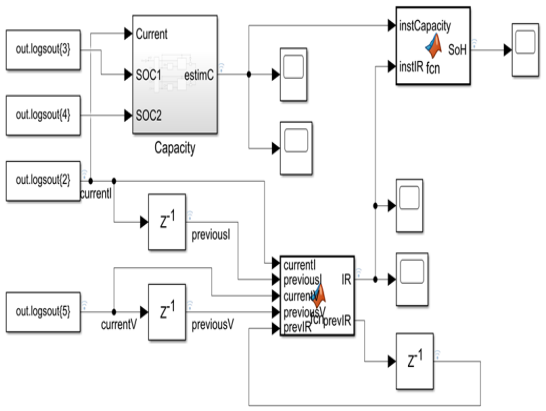

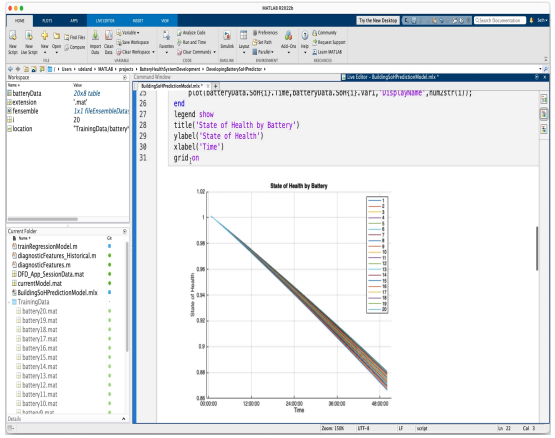

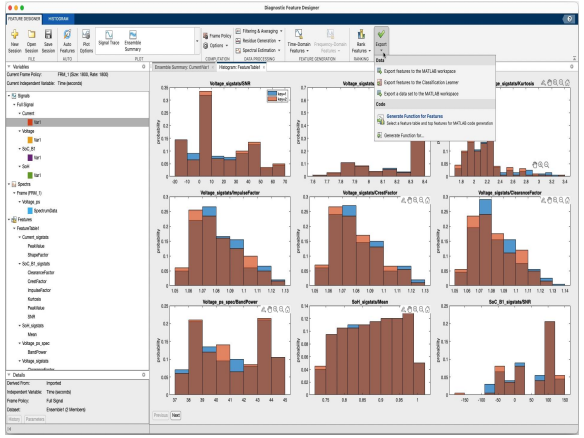

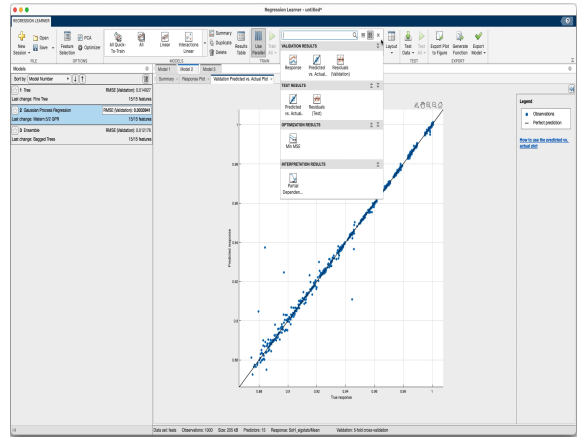

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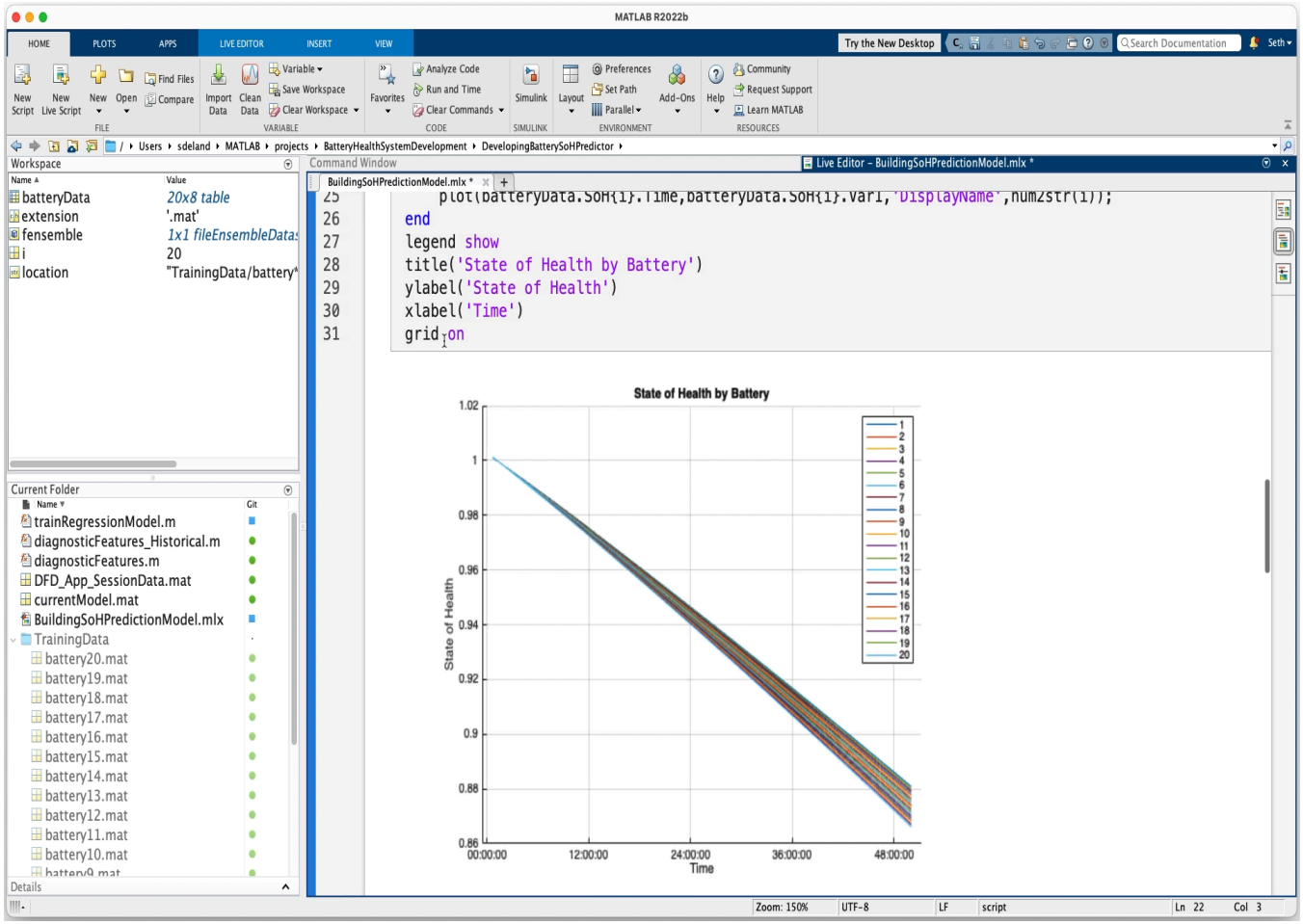

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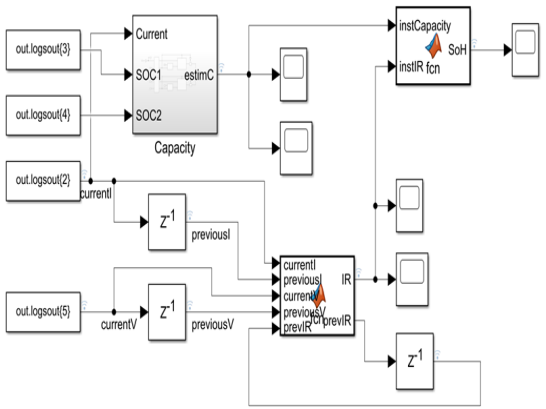

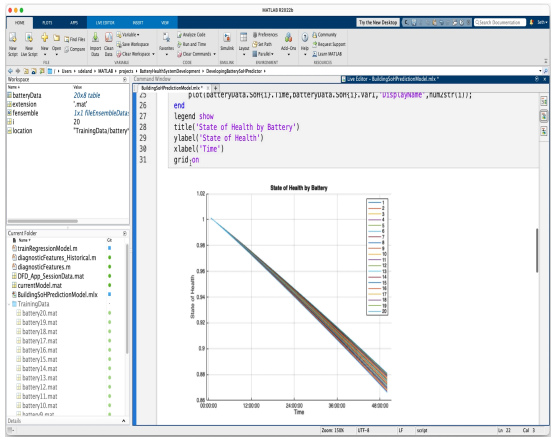

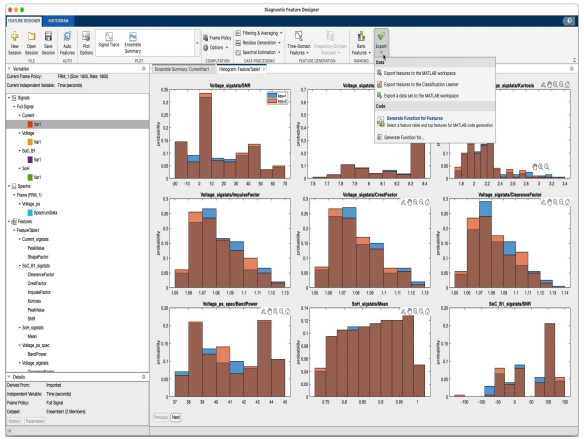

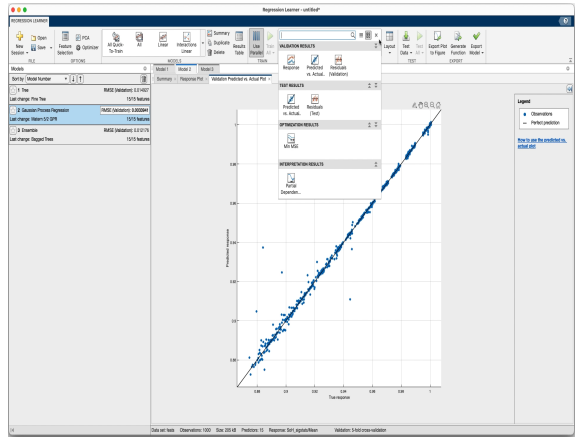

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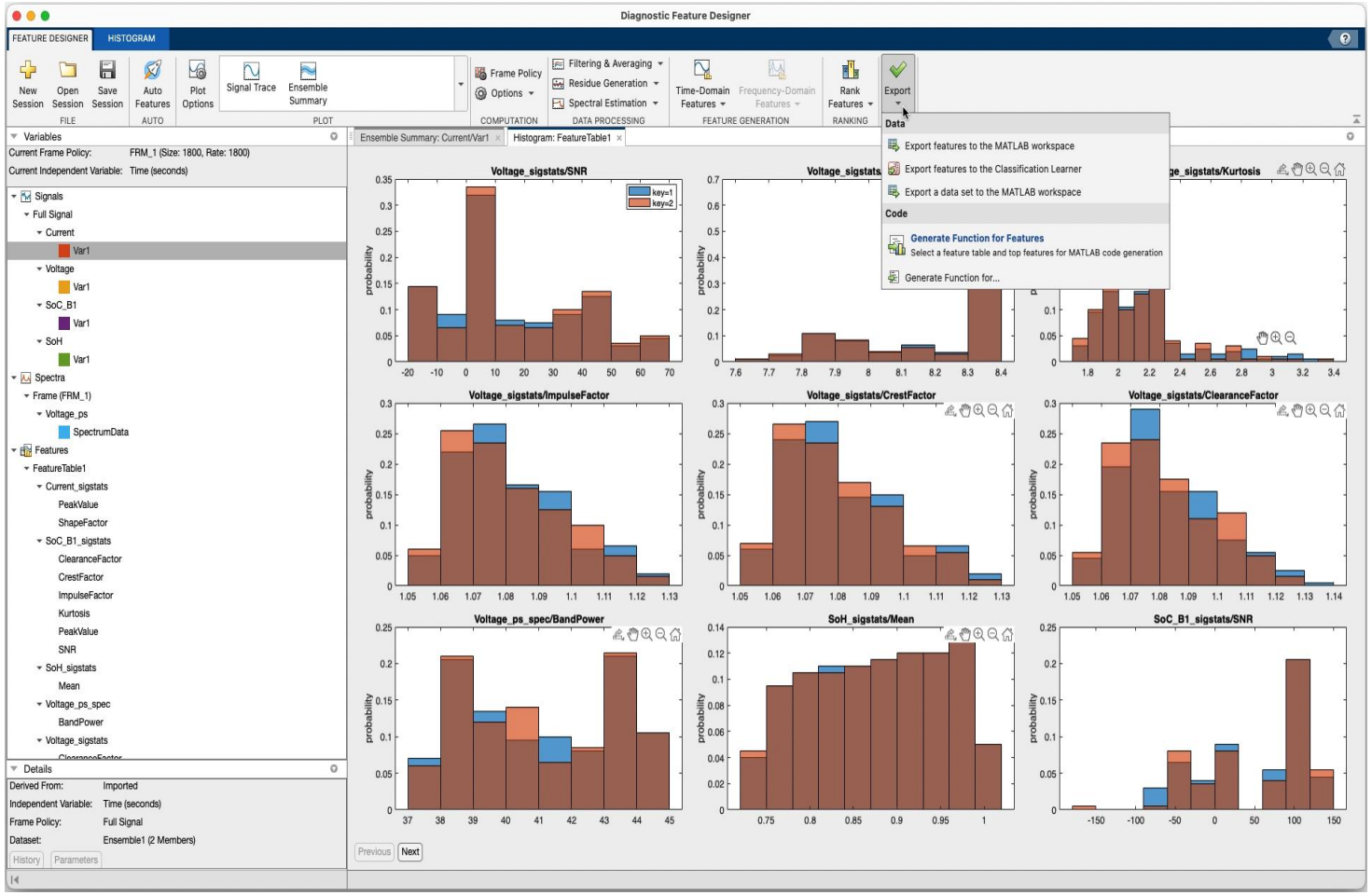

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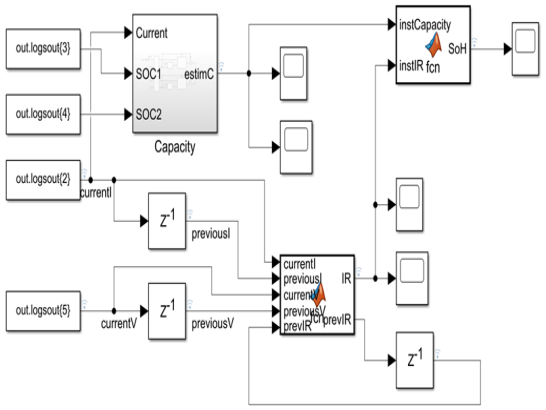

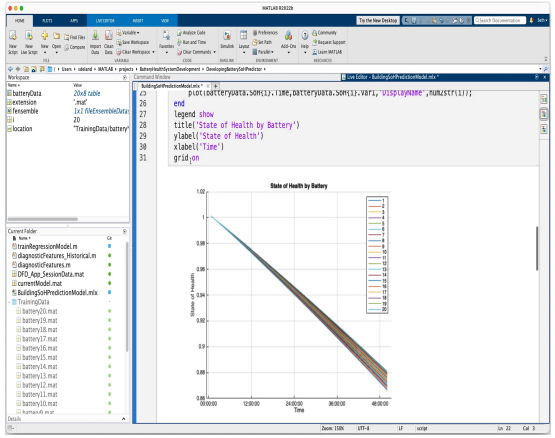

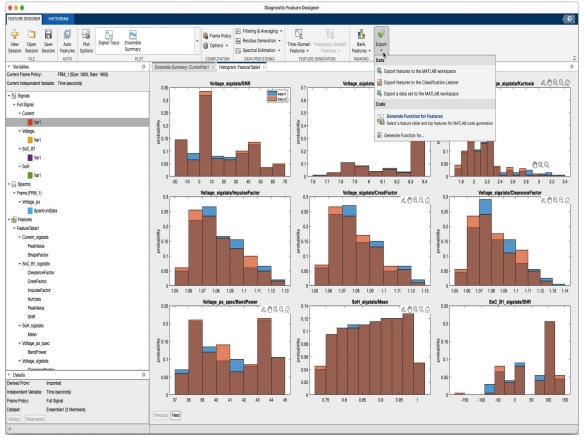

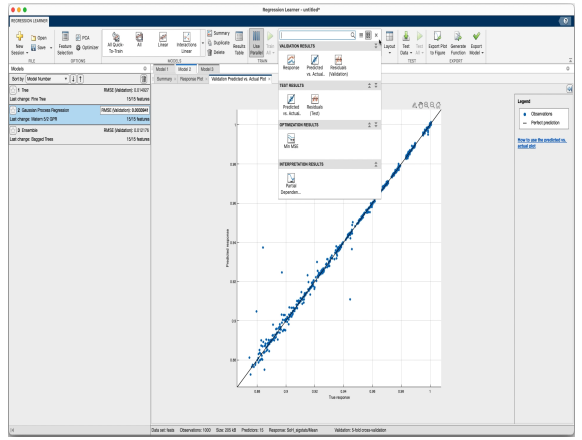

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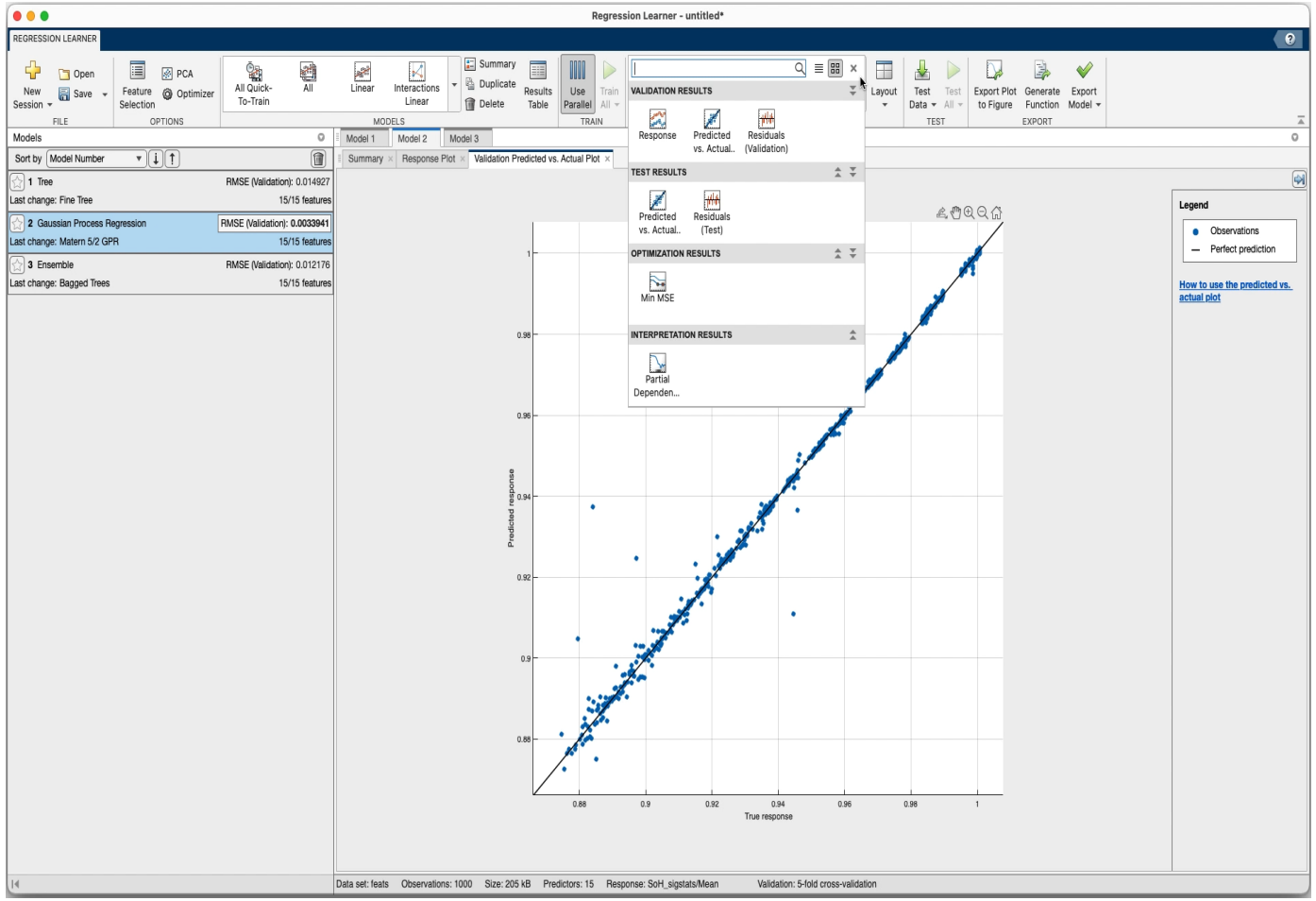


Data labeling → **Data Exploration** → **Feature Extraction** → **Machine Learning**

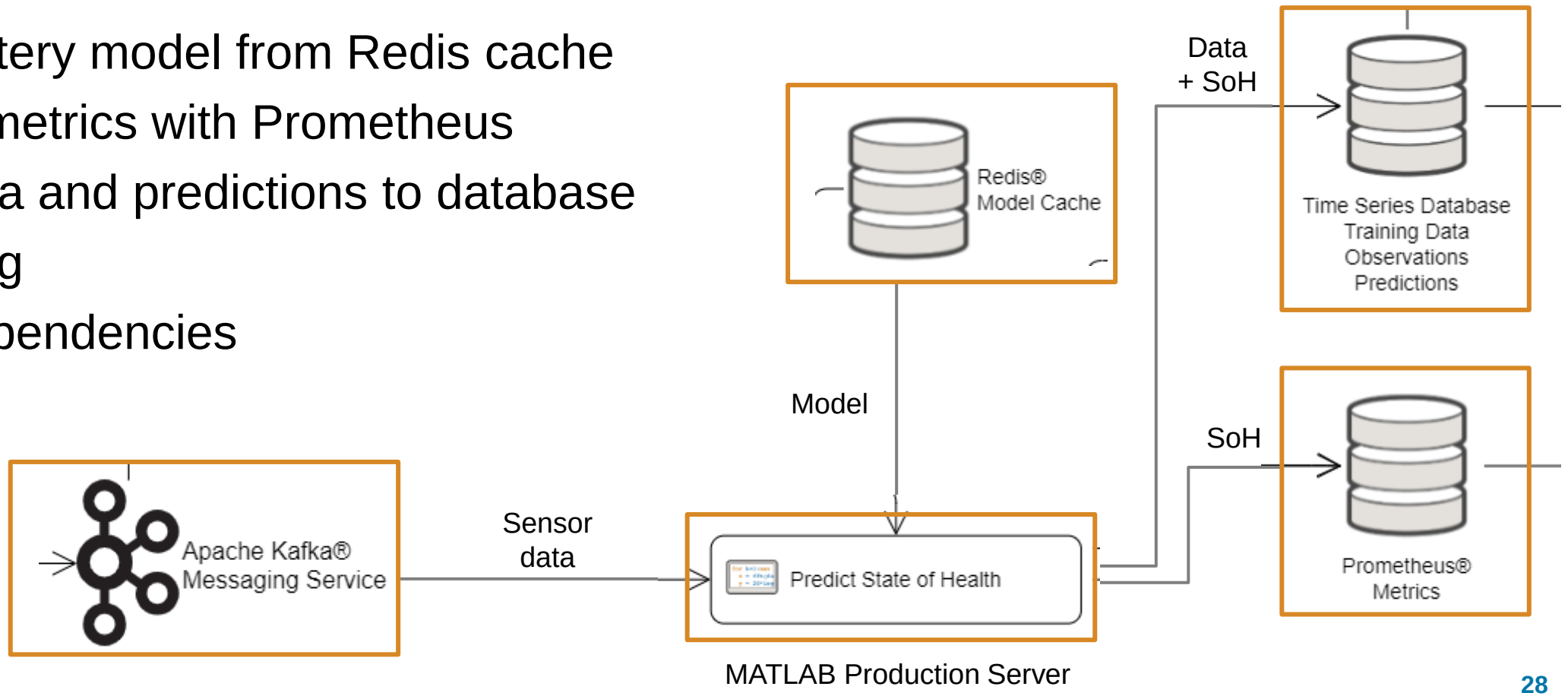
State of health algorithm in production

Production System

- Receive sensor data as kafka stream
- Load battery model from Redis cache
- Expose metrics with Prometheus
- Save data and predictions to database

Local testing

- Mock dependencies



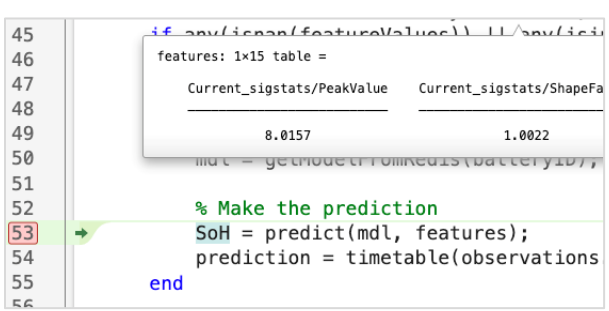
Write SoH prediction function to simulate or use Kafka streams

Stream from files on disk

```
inKS = testStream(...
...
esp = eventStreamProcessor(inKS,...
```

Stream from network

```
inKS = kafkaStream(...
...
esp = eventStreamProcessor(inKS,...
```



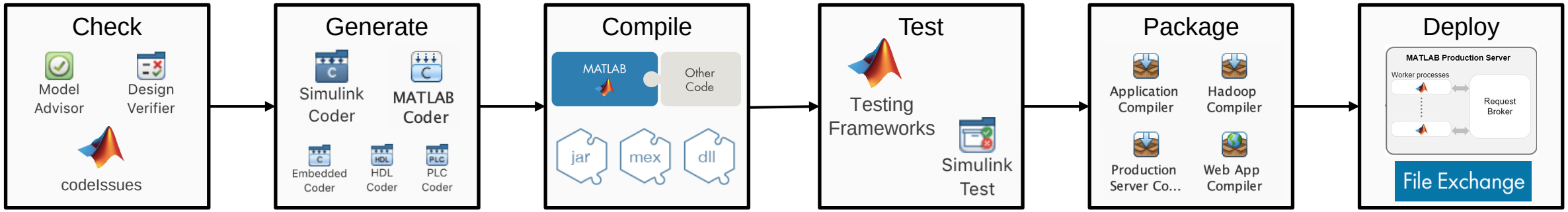
MATLAB Desktop

f(x)

MATLAB Production Server

Debug locally, then deploy the same MATLAB code to production.

Use buildtool to automate execution of build tasks




```
function plan = buildfile
plan = buildplan(localfunctions);
plan("packageDriftDetection").Dependencies = "test";
plan("packageSoHPrediction").Dependencies = "test";
plan("test").Dependencies = "validate";
end
```

Automatically build, test, package, and deploy MATLAB code

esteinerMW / Battery-Health-Estimation-Streaming-Demo Private

forked from mathworks/Battery-Health-Estimation-Streaming-Demo

Code | Pull requests | Actions | Projects | Wiki | Security | Insig

← Build and upload deployable archive (CTF) to MATLAB Production Server

update battery dashboard #19

Summary

Jobs

build

Reset Demo Operations

Run details

Usage

Workflow file

build

succeeded 12 hours ago in 3m 41s

- Set up job
- Run actions/checkout@v3 3s
- Setup MATLAB Support Packages 0s
- Setup MATLAB 30s
- Run MATLAB buildtool
  - 1 ▶ Run matlab-actions/run-build@v1
  - 8 ▶ Generate script
  - 10 ▶ Run command
- Azure login
- Azure CLI script - upload CTF to az file-share
- Post Run actions/checkout@v3
- Complete job

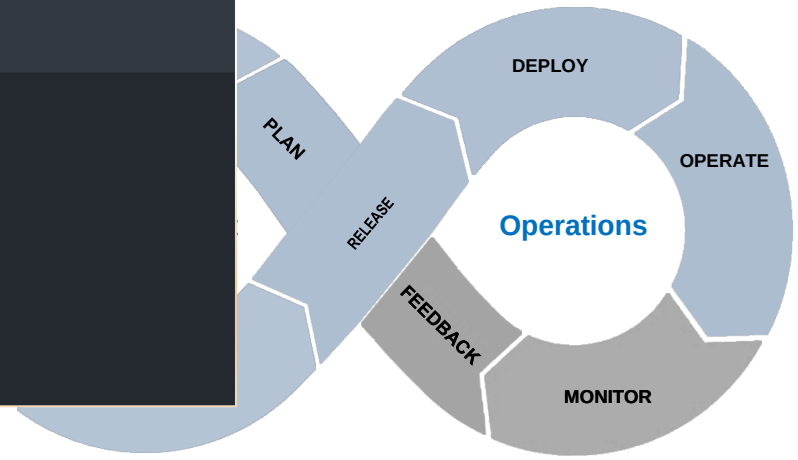
Run MATLAB buildtool

1 ▶ Run matlab-actions/run-build@v1

8 ▶ Generate script

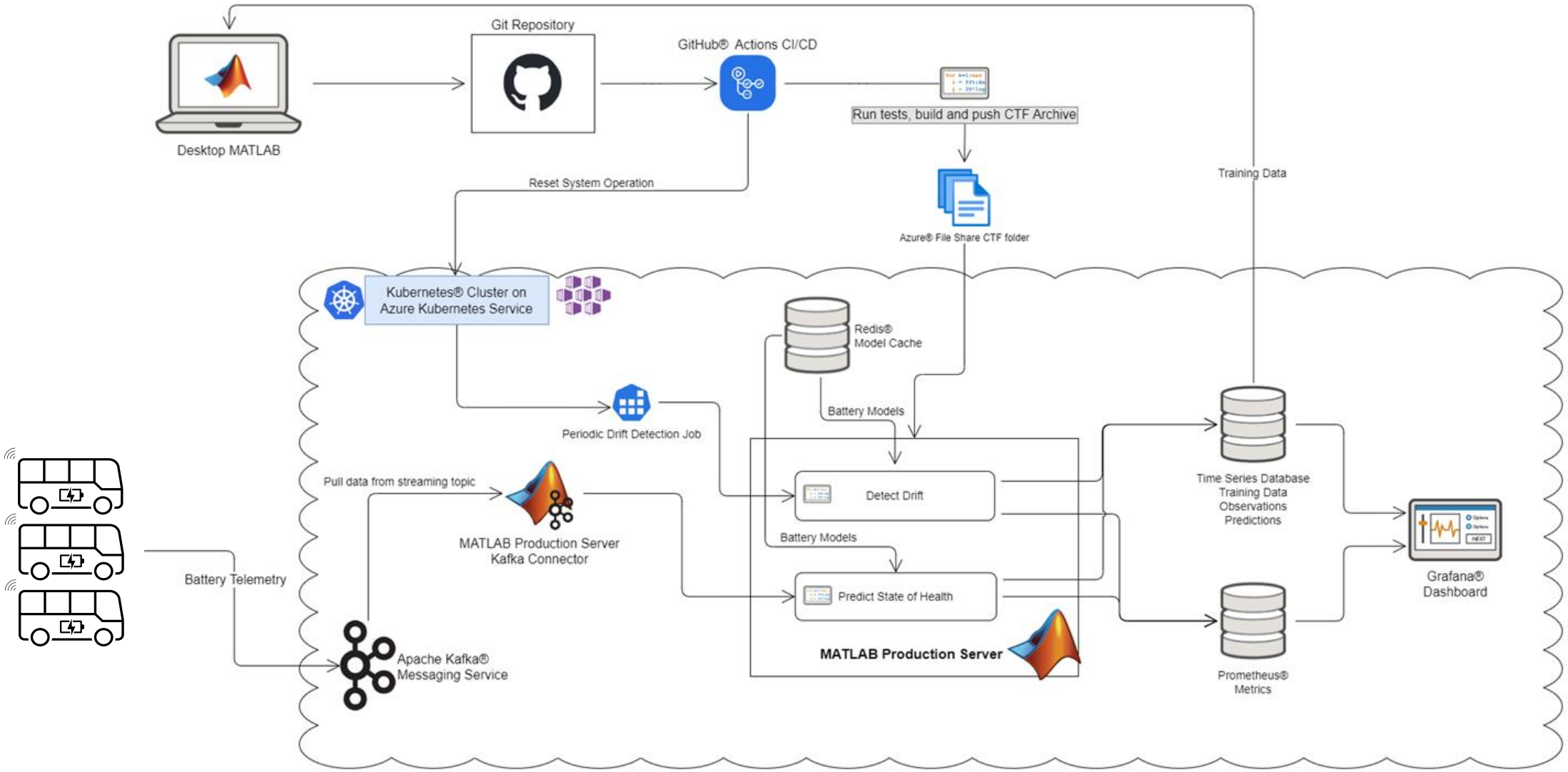
10 ▶ Run command

Azure login

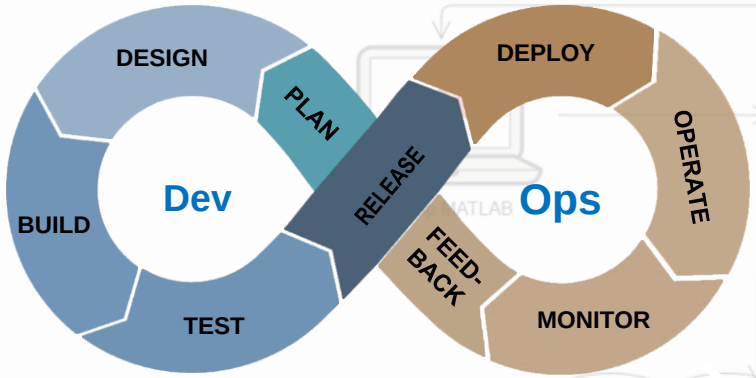



```
- name: Run MATLAB buildtool
  uses: matlab-actions/run-build@v1
  with:
    tasks: packageDriftDetection
```

The Complete System



The Complete System



AI model

MATLAB Developer

Version control system

Automated Deployment

Test & deploy

Streaming data

Deployed functions

Drift detection

AI model

Database

Dashboard

Key Takeaways

Incorporate familiar MATLAB & Simulink capabilities in a DevOps workflow

Integrate with production systems to transition from desktop to cloud

CI/CD

Automatically test, build, and deploy MATLAB code and Simulink models

MathWorks

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Europe

Thank you

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