# MACHINE LEARNING AND CLOUD FOR EV SYSTEM DEVELOPMENT

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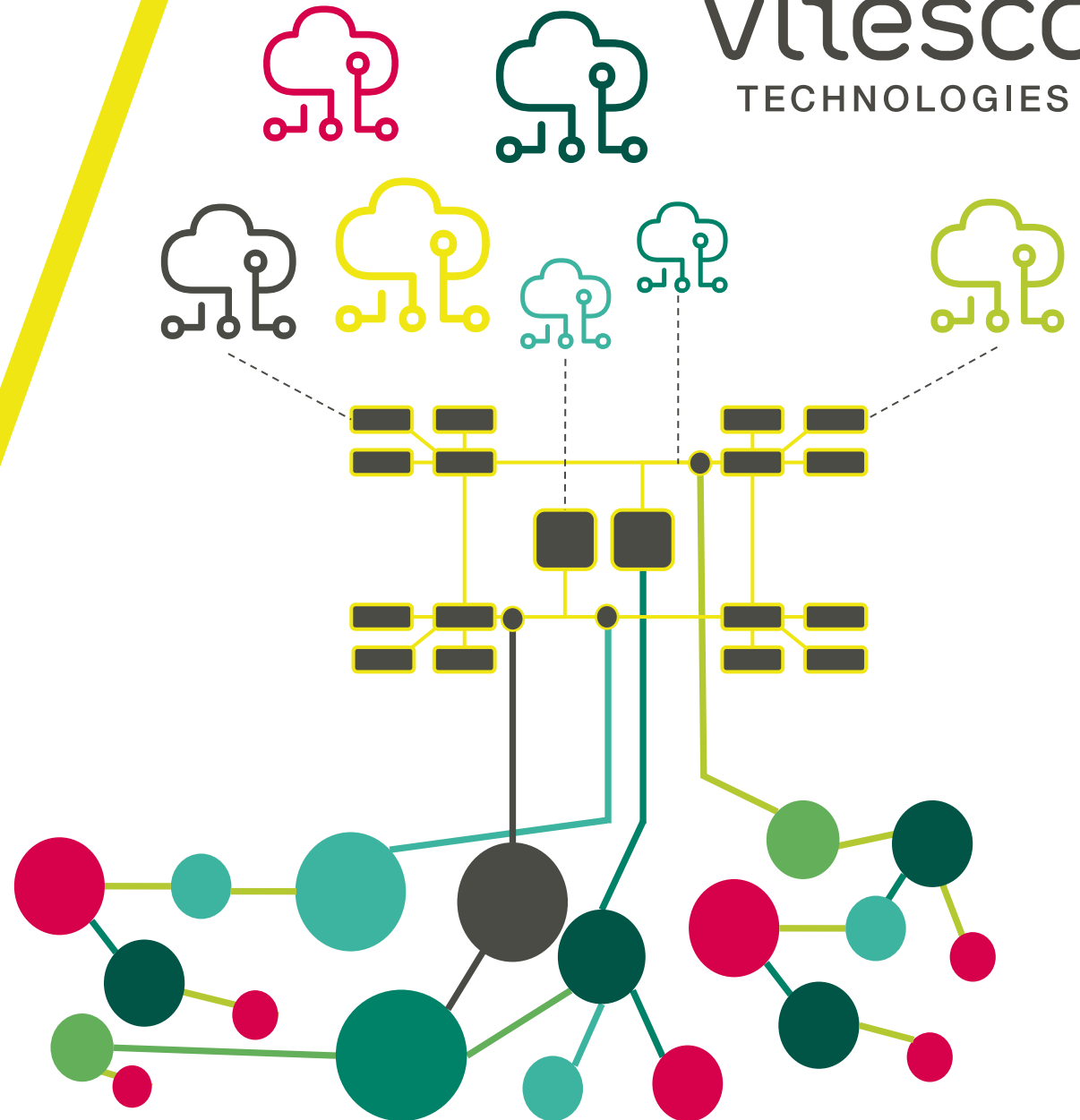
# AGENDA

1   WHY AI FOR EV SYSTEM DEVELOPMENT

2    ALIGNMENT TO PROCESS

3    MODELING METHODS FOR SYSTEM DEVELOPMENT

4   AI FOR PREDICTION IN EV APPLICATION

5   DATAFLOW FOR CALIBRATION

6   ADVANTAGES OF PROPOSED METHOD

7   WHAT WE ACHIEVE

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# ML AND CLOUD FOR EV SYSTEM DEVELOPMENT

WHY AI FOR POWERTRAIN CONTROLS

Accelerated development time

Technology demonstration

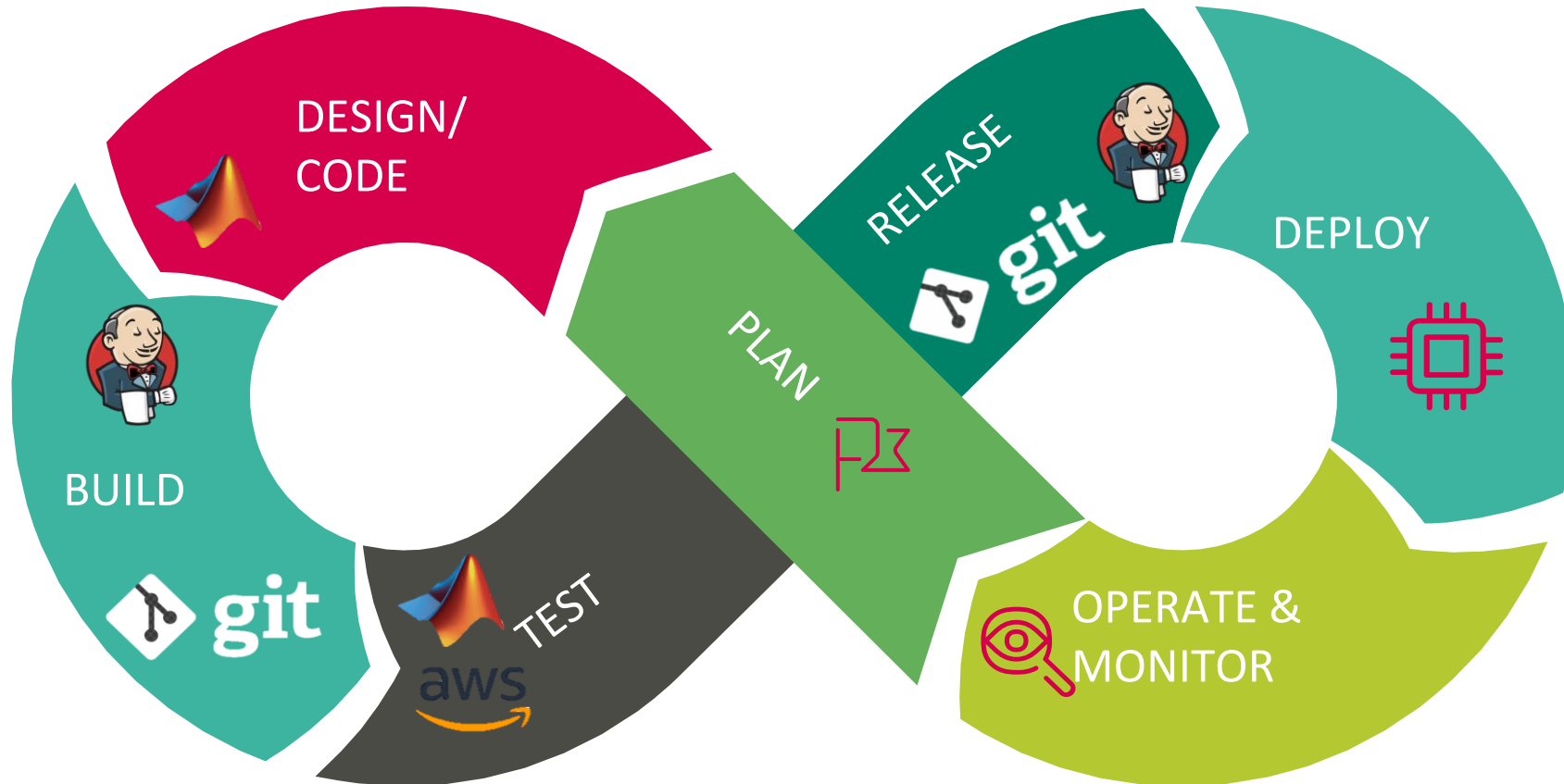Automated calibration

- Cost benefit
- IP generation
- Performance improvement
- Efficiency improvement

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## ALIGNMENT TO PROCESS

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# ML AND CLOUD FOR EV SYSTEM DEVELOPMENT

No space for monster network in Control unit

Limited references for AI in control applications

Usage of AI algorithms in webspace to embedded control algorithms

Quantized inputs triggered at finite step size

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# ML AND CLOUD FOR EV SYSTEM DEVELOPMENT

## MODELING METHODS FOR SYSTEM DEVELOPMENT

### PHYSICS MODELS

✓ You have a **"good enough"** knowledge of the physical model

✓ You know how to implement it

✓ Must satisfy constraint

✓ White box models

✗ Physical model not always available

### ML + PHYSICS MODELS

✓ **partial knowledge** of the physical model

✓ Have "enough" data to complete this knowledge

✓ You ensure generalization of solvers

✓ Can fit easily highly nonlinear function

✗ Solver design and hybridization with data models

### ML MODELS

✓ Physical knowledge is mandatory

✓ You have "enough" data which cover the input space

✓ Ensure generalization by classic regularization

✓ Can fit highly nonlinear function

✗ Black box model. Generalization challenge

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## AI FOR PREDICTION OF COMPONENT TEMPERATURE

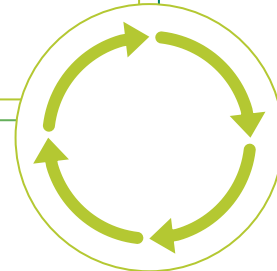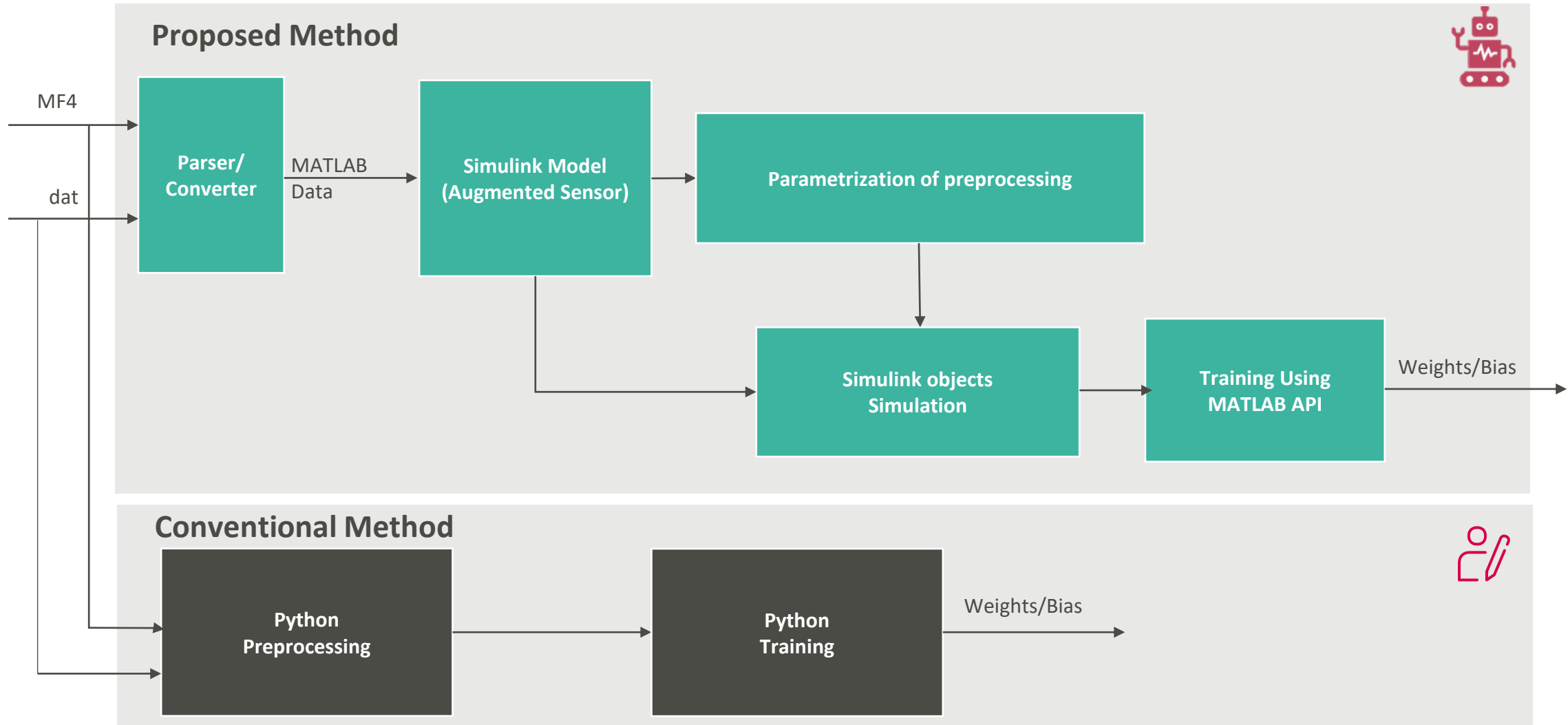| What is solved | How is it solved |
|---|---|
| > Component temperature | > Neural Networks<br>> Model based development  -  Embedded control<br>    > AWS         -  Calibration of control model |
| > Data and Parameter management<br>> When training accuracy is not met in field<br>> Review of the training and test dataset | > Diagrammatic representation and Easier code generation<br>> Effective and efficient maintainability<br>> Ease to use by effective data management |
| **Challenges and Learnings** | **Advantages of proposed method** |

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## PROPOSED VS CONVENTIONAL METHOD FOR CALIBRATION



**Proposed Method**

MF4 → Parser/Converter → MATLAB Data → Simulink Model (Augmented Sensor) → Parametrization of preprocessing

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Simulink objects Simulation → Training Using MATLAB API → Weights/Bias

**Conventional Method**

Python Preprocessing → Python Training → Weights/Bias

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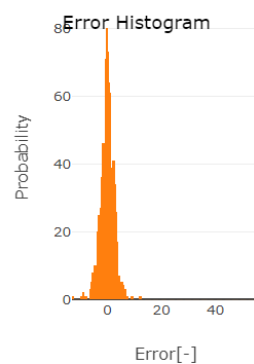
# ML AND CLOUD FOR SYSTEM DEVELOPMENT

## ADVANTAGES OF PROPOSED METHOD

| Feature | Conventional method | Proposed method | Advantages |
|---|---|---|---|
| Measurements Parsing | ASAM parser | ASAM parser | |
| Data handling for Neural Network | No quantization of data<br>Data not sampled | Quantization of data<br>Data sampled - rate of control unit | ✓ |
| Preprocessing of inputs | Not 1:1 with Microcontroller model | 1:1 with Microcontroller model | ✓ |
| Iterative update of preprocessing parameters | Needs to be updated Manually | Update in GIT<br>pipeline takes care | ✓ |
| Training of Neural Networks | With MATLAB/Python APIs | With MATLAB API | |
| Retraining of neural network - validation | Needs to be updated Manually retraining needs to be done | Update in GIT<br>Preconfigured pipeline | ✓ |
| Maintenance | Controller model and python model maintenance<br>Sync of parameters – Python and Controller | Controller model used in pipeline<br>Same parameters repo – controller and AWS | ✓ |

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## PROPOSED DATA FLOW FOR CALIBRATION



> Easier and efficient Parametrization.
> Blackbox pipeline – end user
> Effective usage of ASAM parser for measurement data parsing and processing

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## RESULTS AND ADVANTAGES
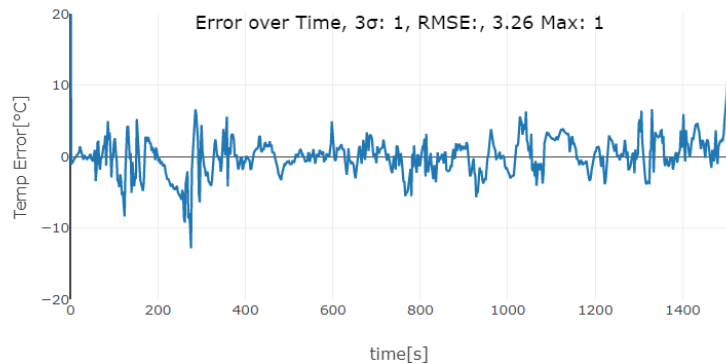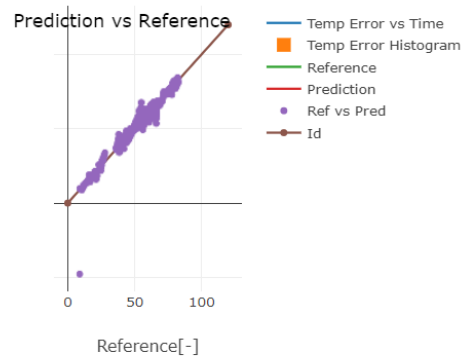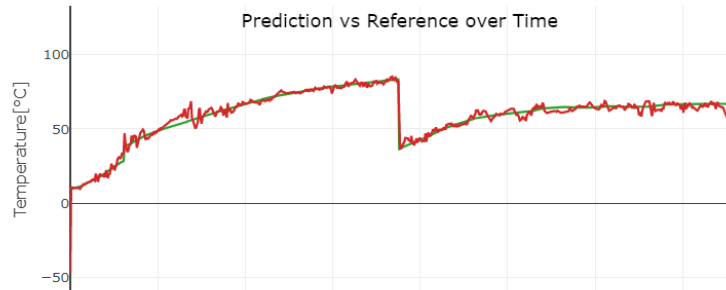


Parameters file easily downloadable from APP

> Output temperature predicted is quite accurate
> Error MSE < 1%
> Parameters of the network can be downloaded
> Used for validations with minimum effort

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# ML AND CLOUD FOR SYSTEM DEVELOPMENT

Effective use of AI/ML for system development

Fit AI for many applications onto limited hardware

Usage of AWS for Model based calibration

APP based development

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LETS
DISCUSS

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