

Model Management Service:

A custom PUS Service for Flexible Handling of Machine Learning Models on Board Space Systems

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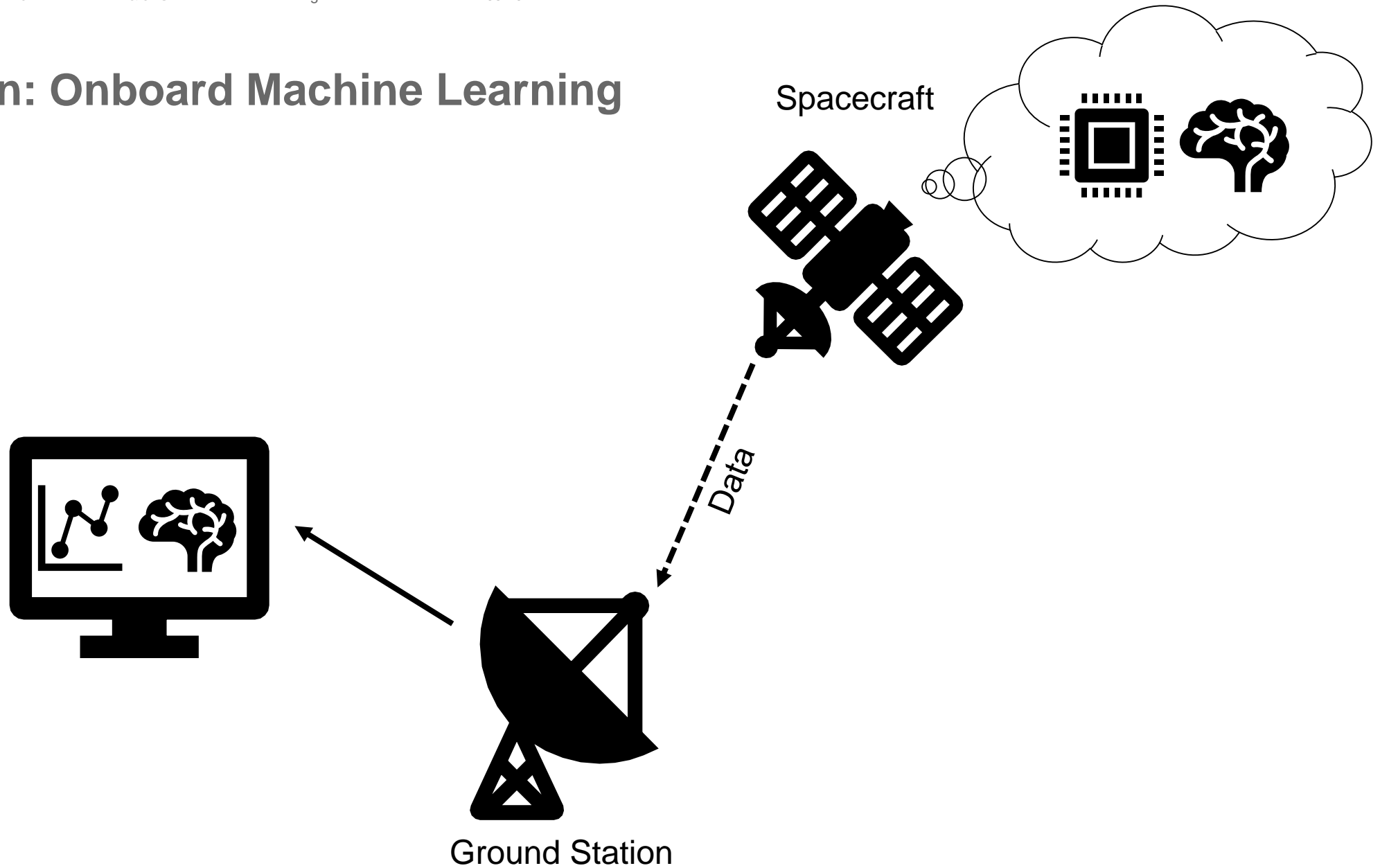
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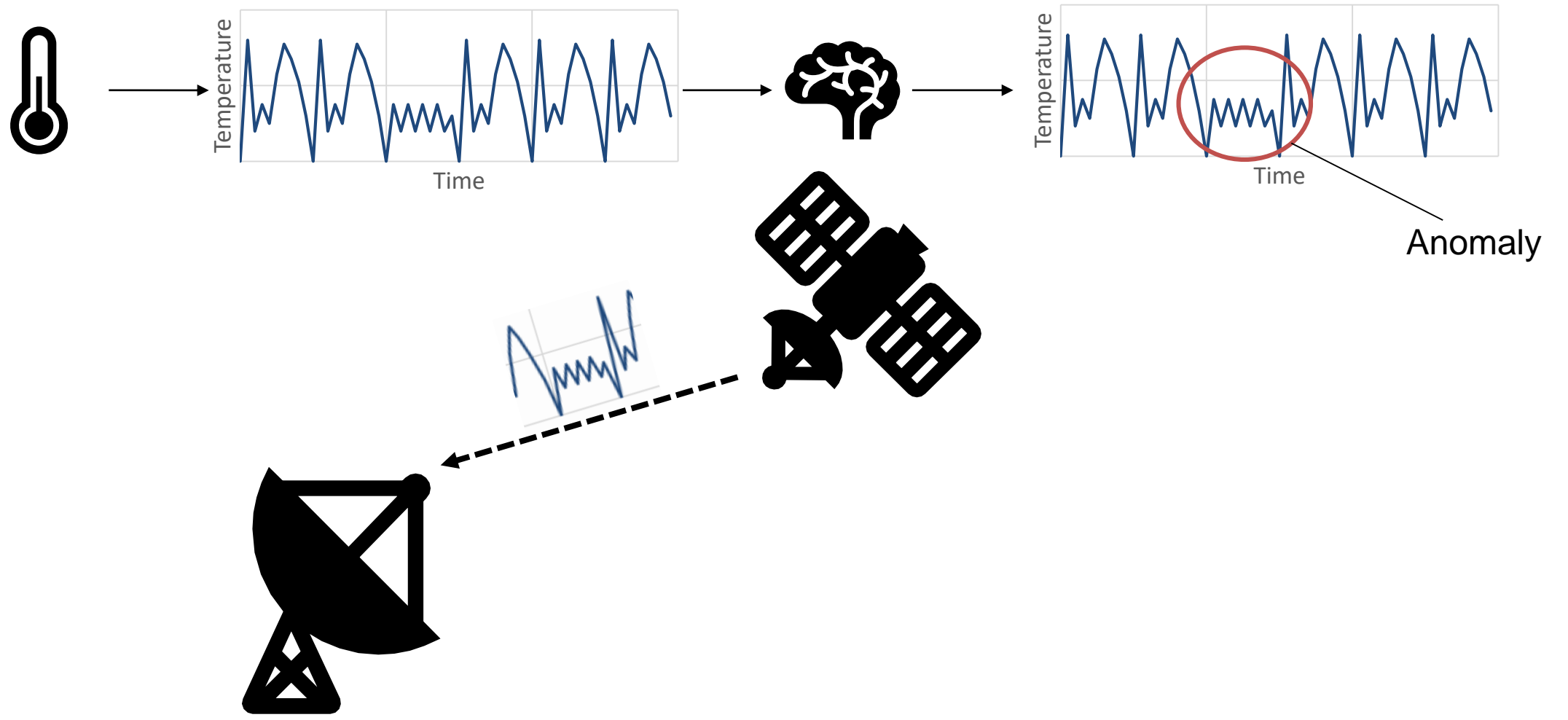
Knowledge for Tomorrow



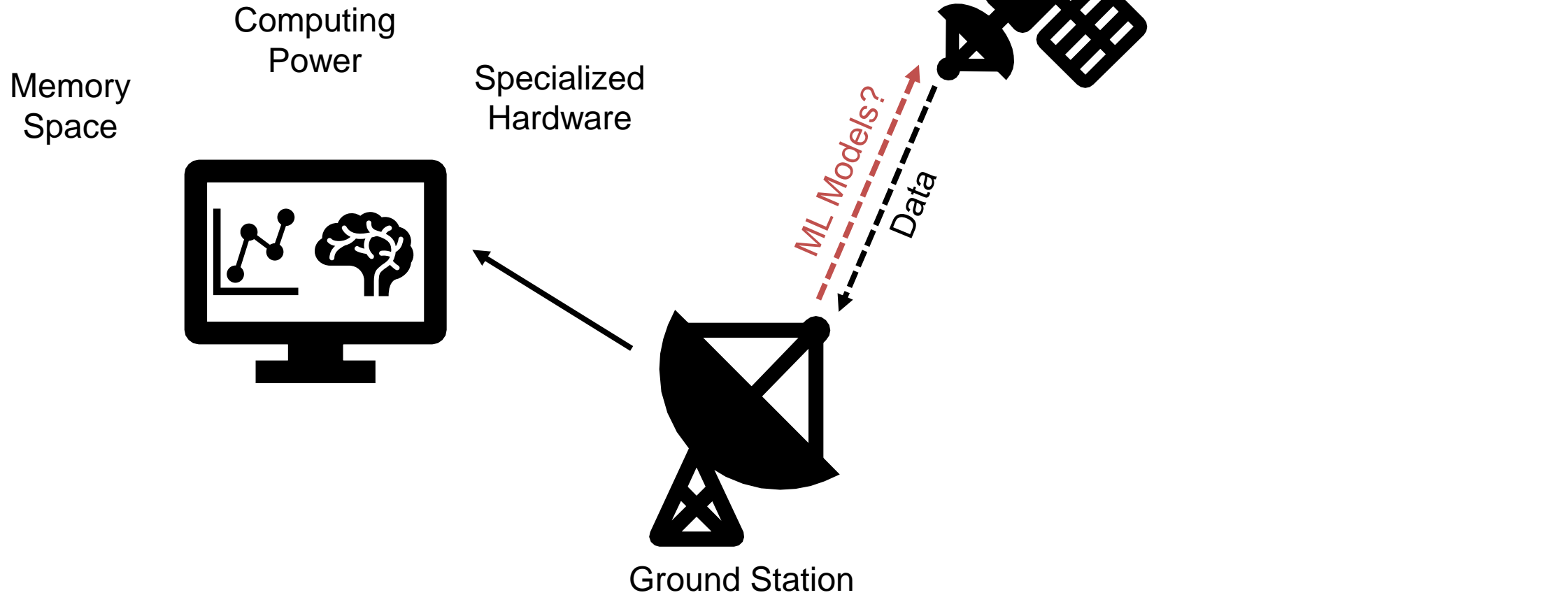
Motivation: Onboard Machine Learning



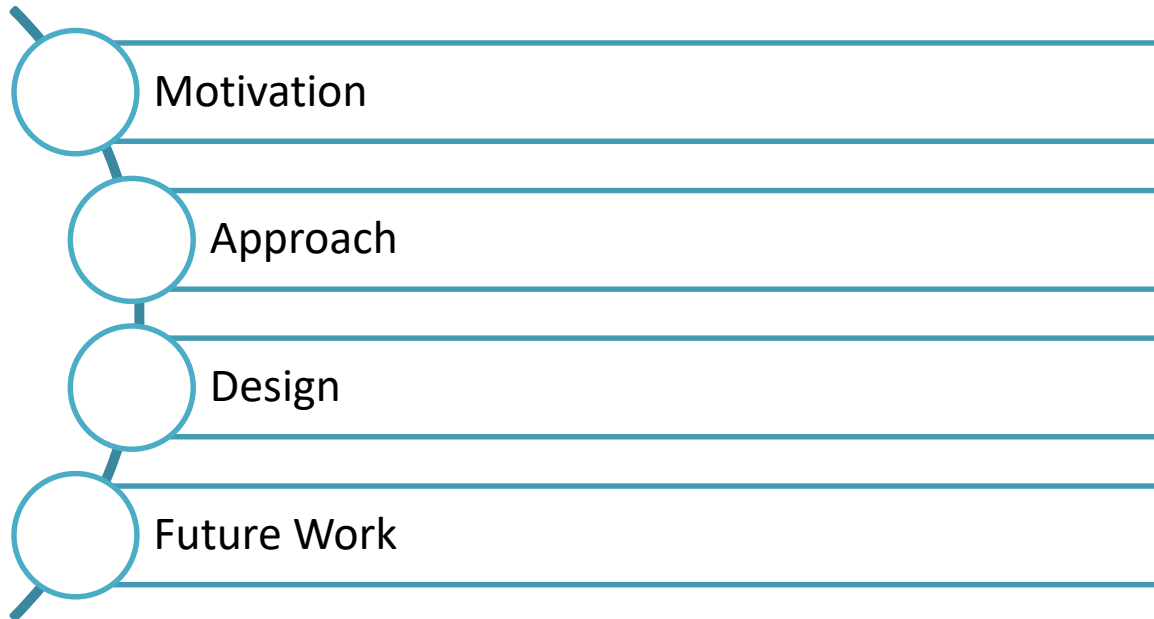
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Agenda



Approach

- Custom service for dynamically uploading ML models on board spacecrafts
- Based on Packet Utilization Standard (**PUS**, cf. ECSS-E-ST-70-41C)
- Integrated into the Open ModUlar software PlatfOrm for Spacecraft (**OUTPOST** ¹)
- OUTPOST available as **Open Source** software (contact Jan-Gerd.Mess@dlr.de)
- Based on and currently limited to models created with **TensorFlow** (TF)/ **TensorFlow Lite** by Google

¹ <https://github.com/DLR-RY/outpost-core>



Design

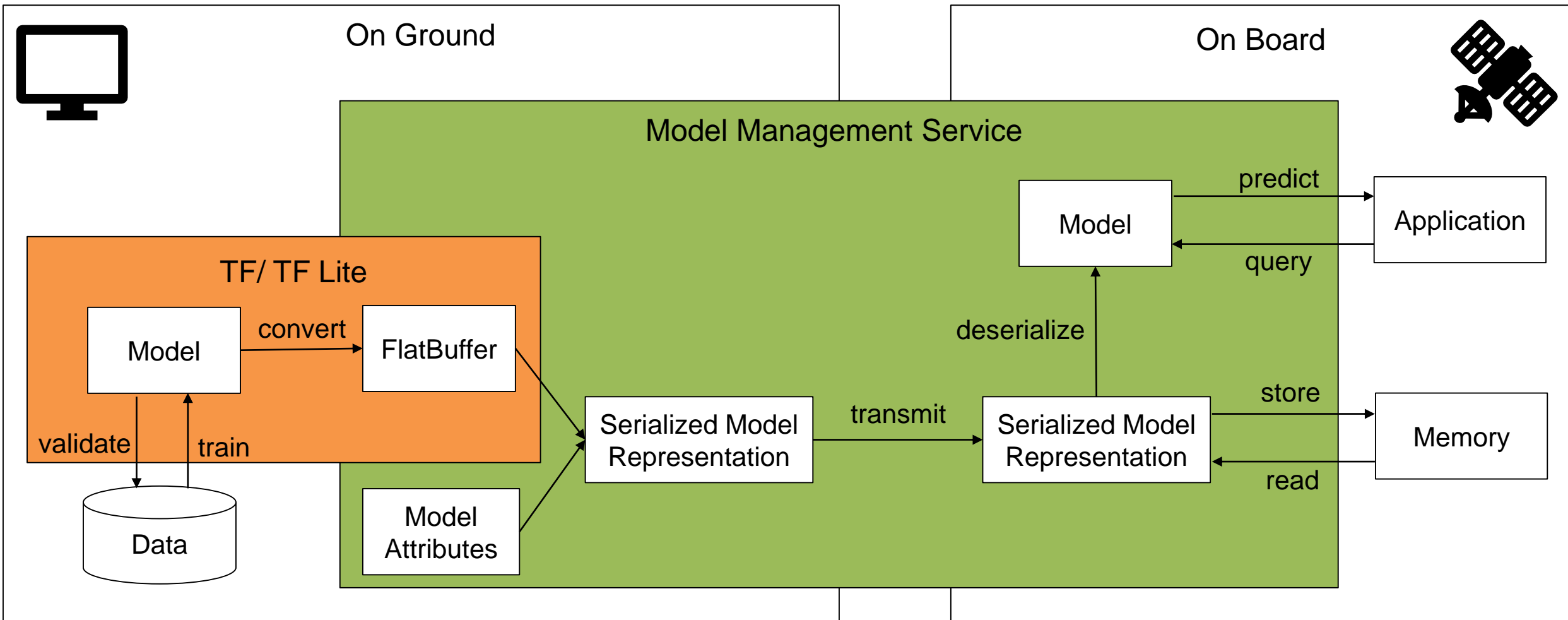
Why TensorFlow/ TensorFlow Lite?

- TF Lite: Extension of TF
- Enables to deploy TF models to mobile and embedded devices
- Creation, training and validation of models using TF
- Model conversion into a serialized representation (FlatBuffer) using TF Lite
- Reduction of required memory space

References: [1], [2]



Design Overview



Design

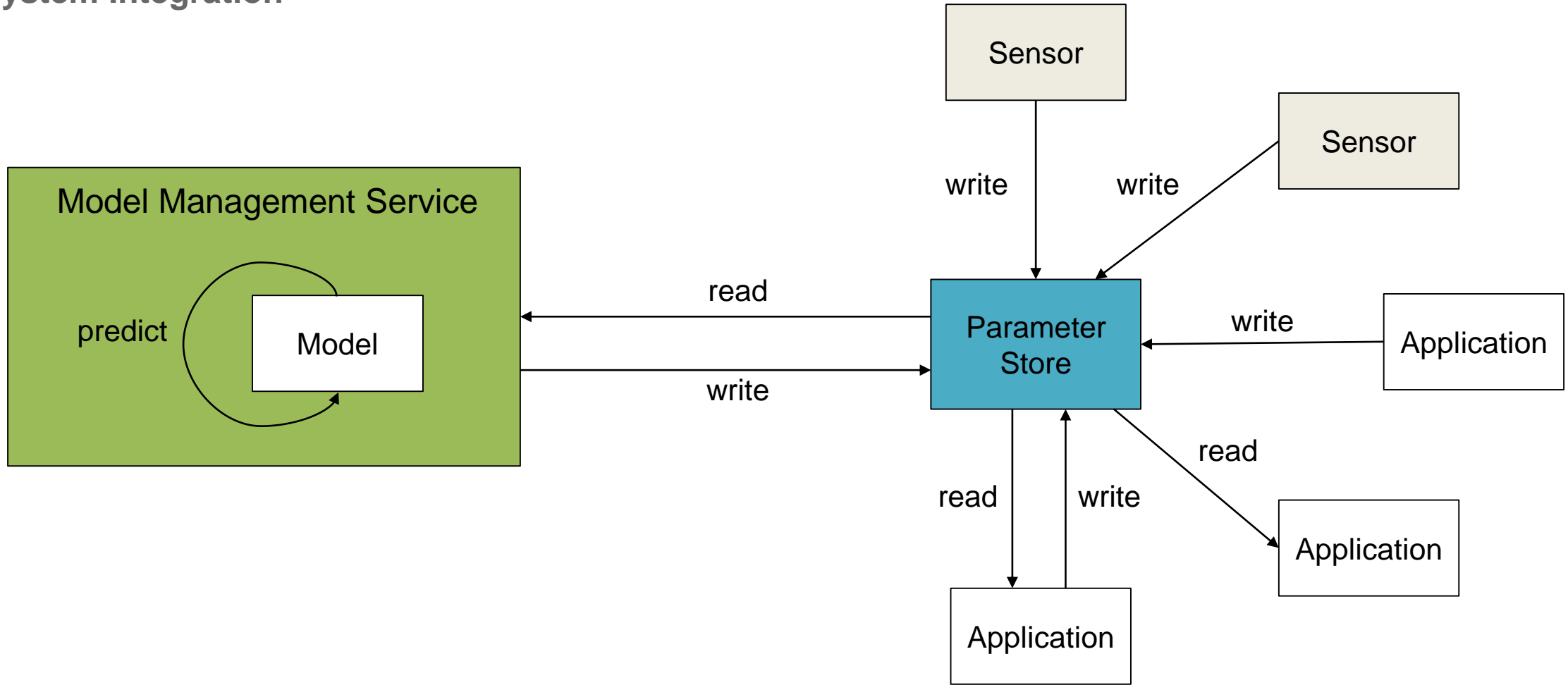
Functionalities

- Model upload and deletion
- Model versioning enables model updates
- Model execution triggered by:
 - Event generation (=> PUS Event-Action Service)
 - Periodic scheduling
 - Manual Telecommand (=> Model Management Service)
- Exchange of data between applications and Model Management Service via the OUTPOST Parameter Store
 - Loose coupling between applications
 - System-wide models



Design

System Integration



Future Work

- Testing the whole system i.e. TF/ TF Lite in combination with OUTPOST and the Model Management Service on embedded devices and satellite systems
- Deployment to an application (e.g.: anomaly detection) within an extended mission
- Open Questions:
 - How to validate TensorFlow?
 - How to validate the TensorFlow Lite model (i.e. the FlatBuffer)



Thank you for your attention!



References

[1] TensorFlow, “TensorFlow Lite“, <https://www.tensorflow.org/lite/guide?hl=en>, 2021,
[retrieved 07.06.2021]

[2] TensorFlow, “TensorFlow Lite Converter“, <https://www.tensorflow.org/lite/convert?hl=en>, 2021,
[retrieved 07.06.2021]

