



# Infrastructure for running Digital Twins using ESA Ground Segment Systems

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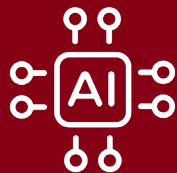
Introduction



Architecture



DT Alignment



AI applications



Ground segment



Demo



Future steps

# Introduction

**Digital Twin (DT):** Dynamic and self-evolving digital representation of the exact S/C state at given time

→ Improve understanding of Spacecraft behavior

→ Support and improve efficiency of FCT tasks

→ Forecast future spacecraft state

→ Detect anomalies



# Introduction: current gaps

**Current infrastructure lacks the mechanisms to...**

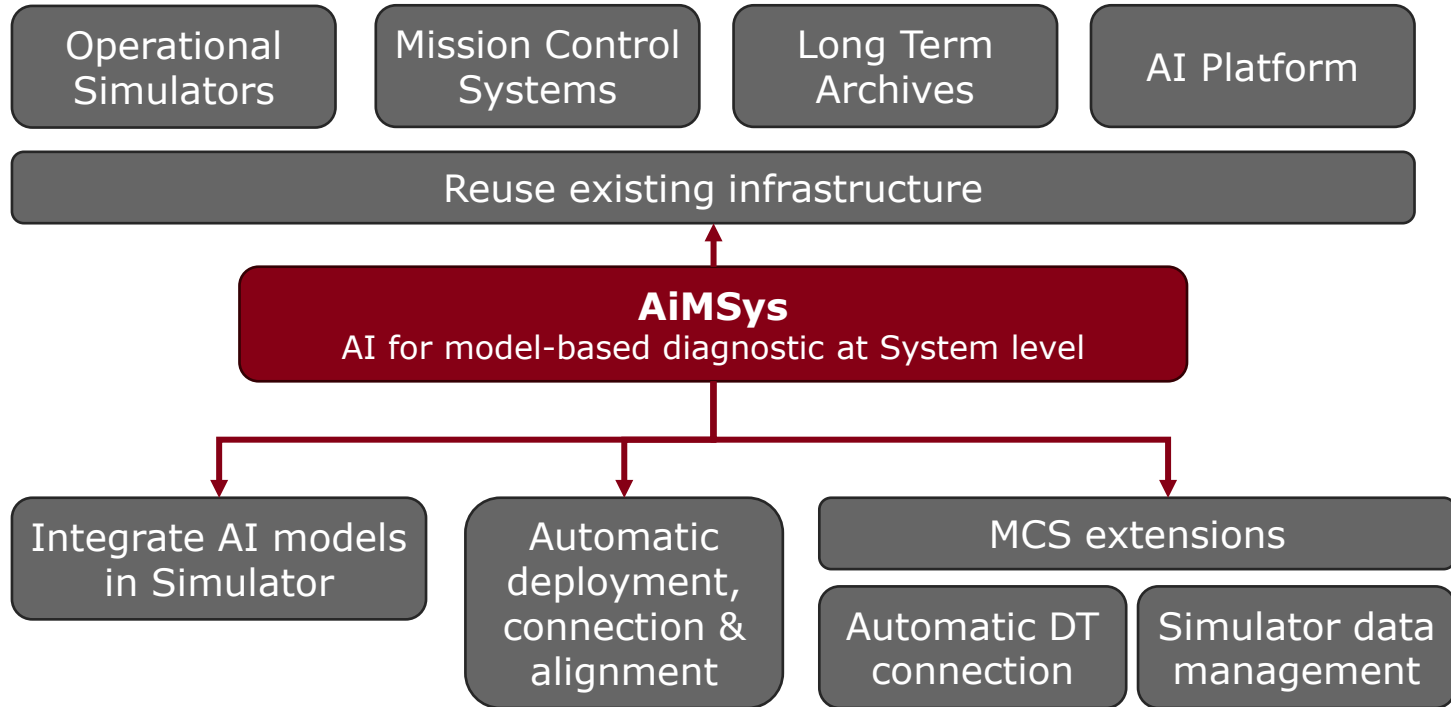
Automatically align simulator state with current S/C state

Quickly recreate past or custom scenarios

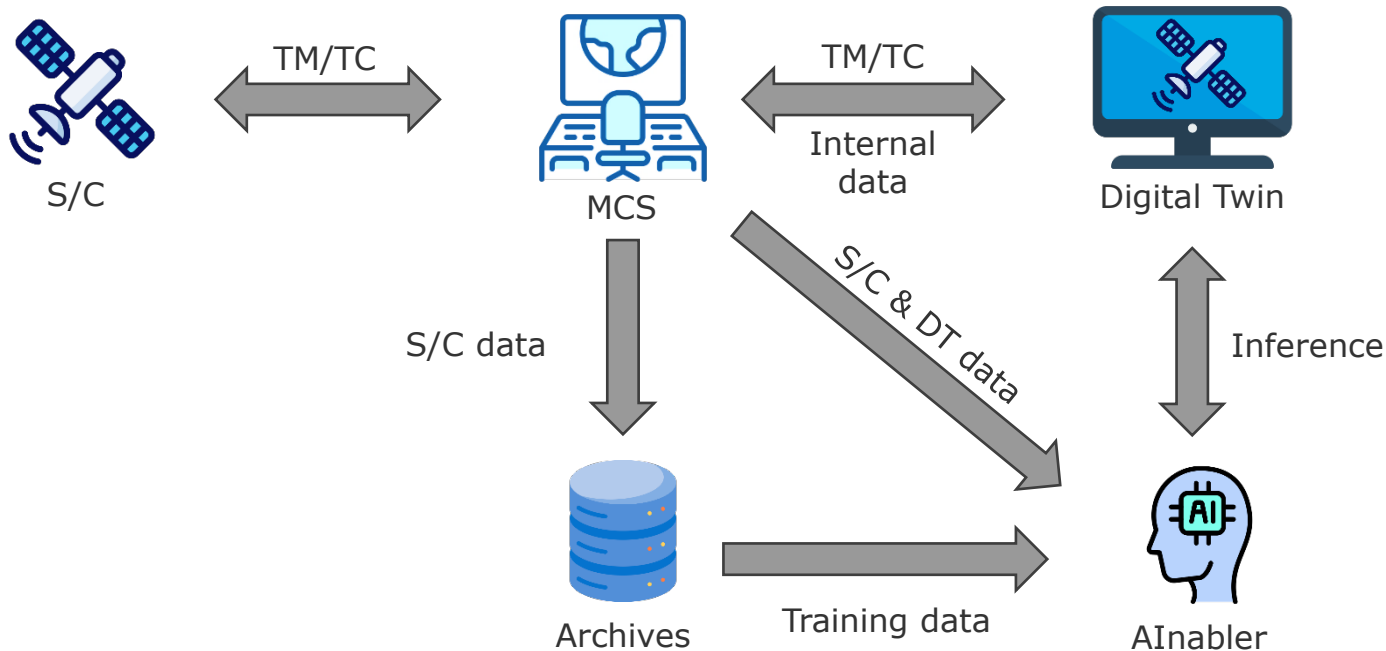
Store and analyze simulator-generated data

Improve simulator fidelity

# Introduction: Proposed approach



# AiMSys infrastructure



# Automatic DT alignment

## State Vector

Formed by S/C telemetry

Defines the S/C state at a certain moment

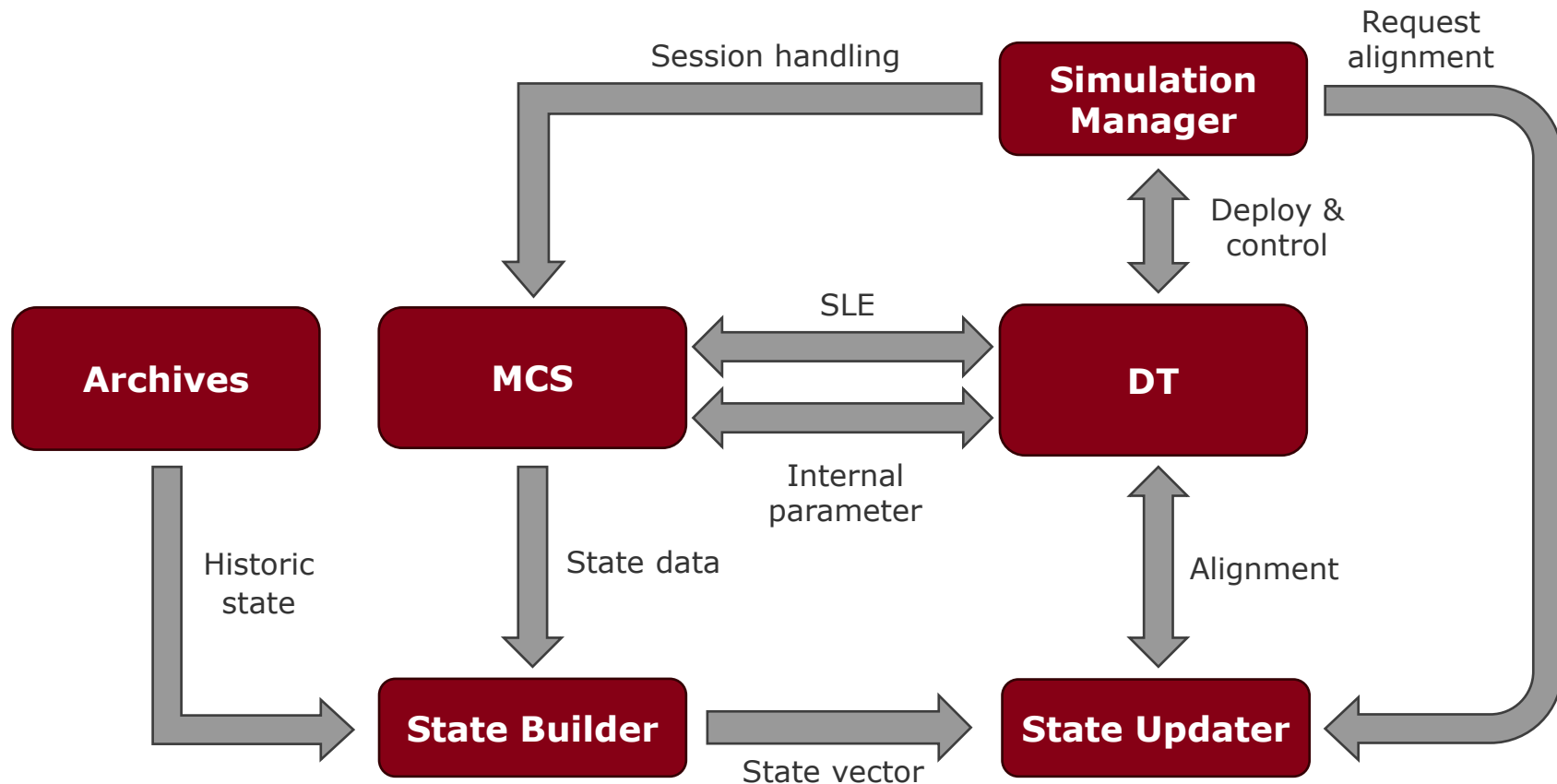
Used as a target state for alignment process

## Alignment

Synchronize operational state

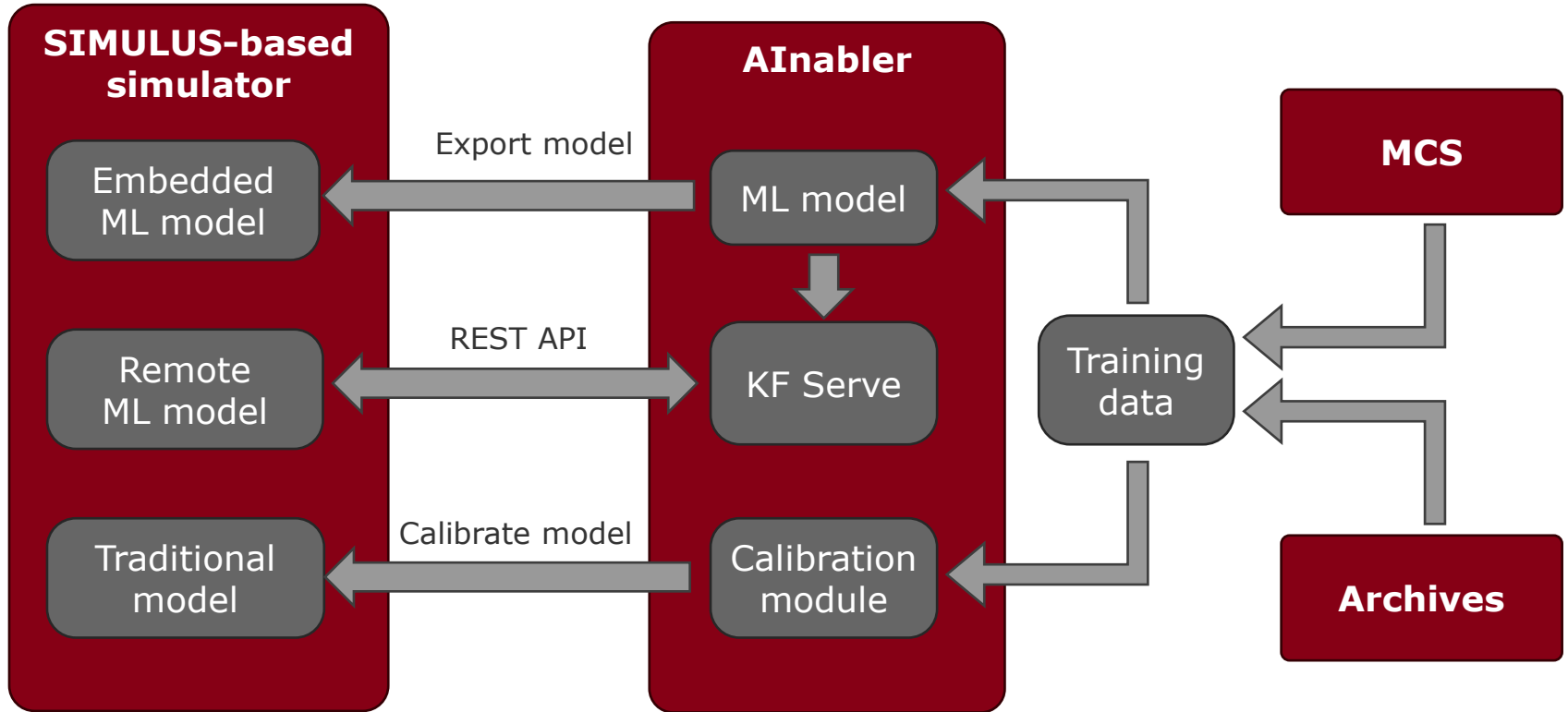
Apply calibration data

# Alignment infrastructure

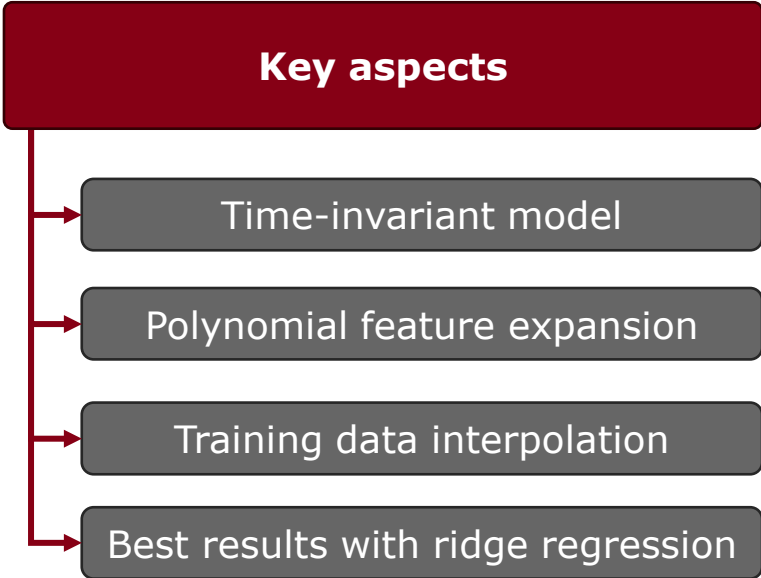
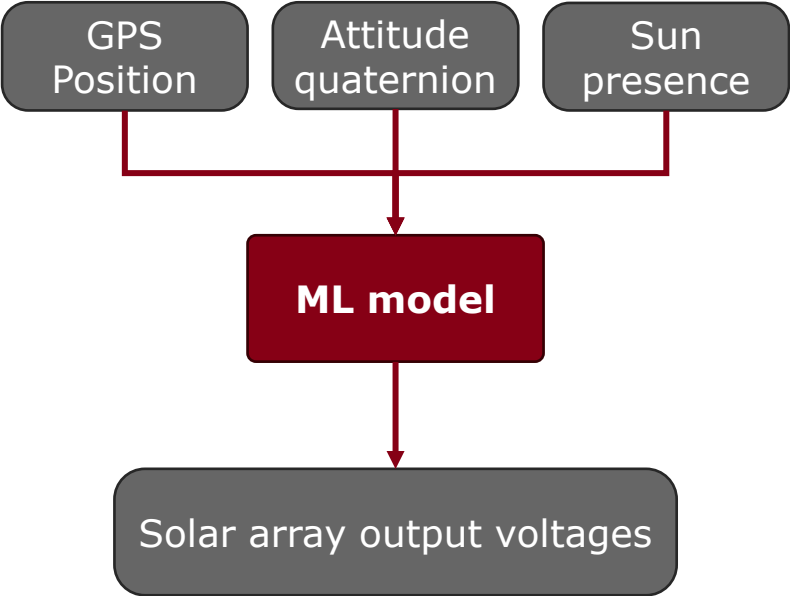




# AI models in DT



# Example: ML model



# Ground Segment Systems

MCS Monitors & Controls DT as if it were a real S/C

Isolated data spaces for DT experiments

Persist internal state of the DT

AInabler can access and compare S/C  
and DT data for analytical purposes

Mission Planning System can evaluate  
scenarios in DT

# Demo



# Demo

The screenshot shows a software interface with a table of parameters and their values. The table has two columns: 'Parameter' and 'Value'. The values are listed in a dropdown menu. To the right of the table, there is a list of 'Expected Values'.

Parameter	Value
AOCS mode	ASH
AOCS auto mode	TRUE
AOCS NM submode	STOPPED
GPS state	STARTED
GPS unit	GPS_A
NAV state	STARTED
IAE state	STARTED
S-BAND TX A	ON
S-BAND TX B	OFF
STR state	STOPPED
STRE unit	STREA
PDHU state	STOPPED

**Expected Values**

- NORMAL
- FALSE
- CAP
- STARTED
- GPS\_B
- STARTED
- STARTED
- OFF
- ON
- STARTED
- STREB
- STOPPED

# Future steps

## Future tasks to achieve a better system:

Analyze DT in different scenarios


Incorporate AI Models to improve simulation fidelity

Continuous synchronization and calibration

Scaling to multiple subsystems and the entire spacecraft

Anomaly detection





**Thank you**  
Questions?

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