AI Driven Autonomous Operation of Process Systems

Chris Kahrs Microsoft
Varsha Raju Microsoft
Dr David Smith AVEVA

Speaker Introduction

Chris Kahrs,
Chris Kahrs is a long time Microsoft employee working in the Data and AI space for the past 7 years.
In his current position as a Technical PM in the Autonomous Systems group at Microsoft he works with Simulation Vendors and Partners to integrate Simulation with the Bonsai (Deep Reinforcement Learning) toolchain. This allows non data science, control engineers to teach the machine to learn an autonomous policy for system control.
Chris holds a Computer Science degree from The Citadel, in Charleston, South Carolina.

Dr. David Smith
Senior Analytical Solutions Engineer, AI Center of Excellence, United Kingdom:
Dr. Smith is a Chartered Mechanical Engineer and holds a Ph.D. in Fluid Mechanics from Imperial College London. Until 2018 he worked in the industry mainly for EPC companies, leading design, development, and commissioning of Power Plant processes and combustion systems.
Moving to AVEVA, Dr. Smith joined the AI Center of Excellence where his main activities are the integration of AI technologies with AVEVA's first principles simulation products as well as being an SME for Power.

Varsha Raju
Varsha Raju is a Principal Program Manager in the Microsoft Bonsai team, which is part of Microsoft AI. She has over 20 years of experience working in partnerships, go-to-market, and engineering roles in industrial settings. She has worked with a diverse set of companies, including those in aerospace, chemicals, discrete manufacturing, and renewable energy. Varsha holds an undergraduate degree in chemical engineering from the University of Pittsburgh and an MBA from Harvard University. She is based in San Francisco, California.

Credits

David Coe
Bonsai Engineer,
Microsoft

Cyrill Glockner
Director of
Simulation
Partnerships,
Microsoft

Andrea Macri'
Product Manager
AVEVA Dynamic
Simulation,
AVEVA

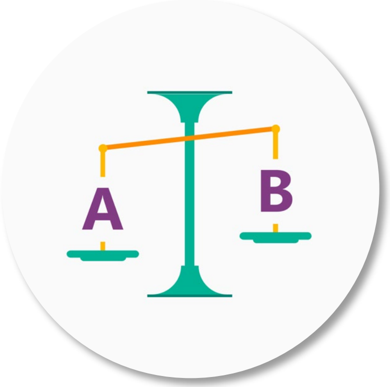
Doug Mills
Senior Consulting
Manager, OTS
Group,
AVEVA

Microsoft

Project Bonsai

Autonomous Systems
Answering ‘Next Optimal Action’?

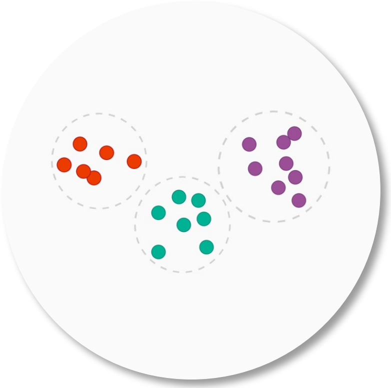
Key questions answered by ML



Is this A or B?

How much
– or –
How many?

Is this weird?



How is this
organized?

What should
I do next?

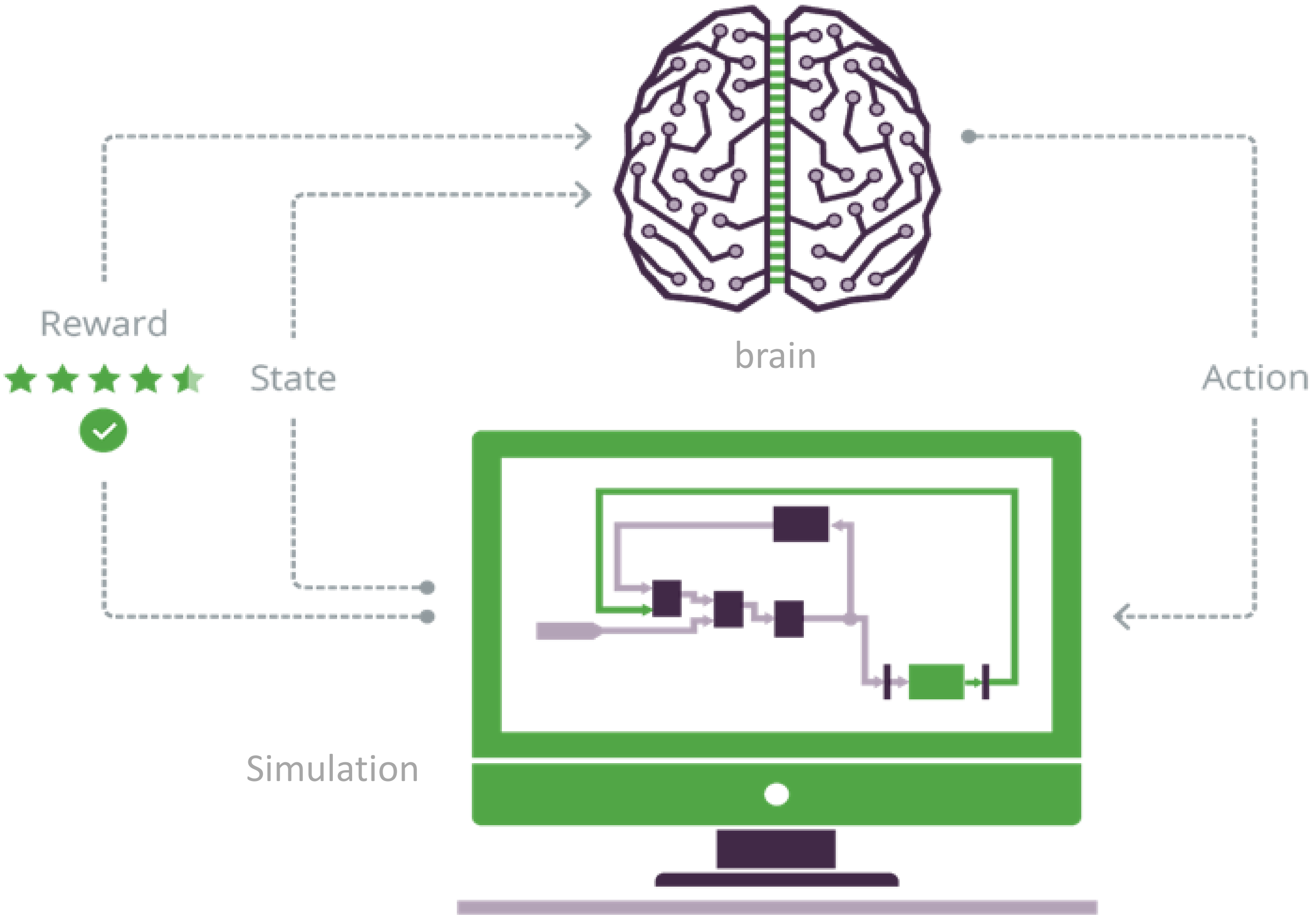
Supervised Learning

Unsupervised Learning

Reinforcement Learning

Building brains for Industrial Control Systems

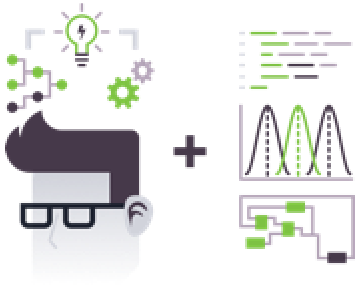
Combining state-of-the-art techniques in DRL, simulations, and machine teaching



Bonsai Service Overview

A complete toolchain to build, train, and deploy brains

1. Machine Teaching injects subject matter expertise into brain training



2. Simulation tools for accelerated integration and scale of training

3. AI Engine automates the generation and management of neural networks and DRL algorithms

4. Flexible runtime to deploy and scale models in the real world

Machine Teaching infuses subject matter expertise into AI models

Machine Learning

Machine Teaching

Scale your subject matter expertise

Achieve faster training times

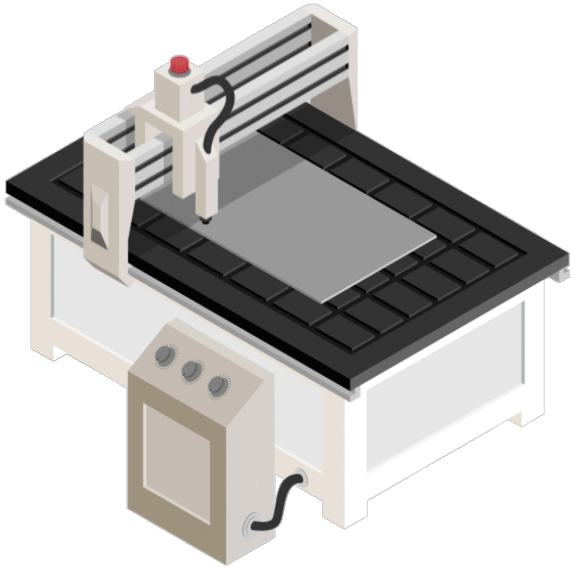
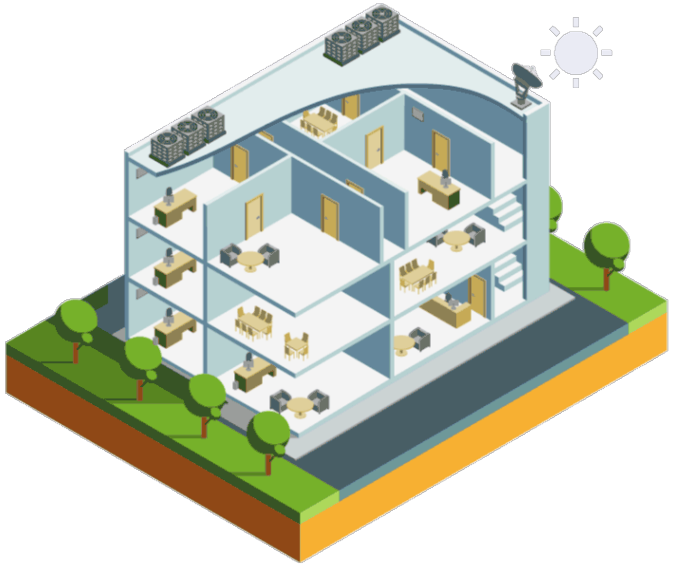
Produce explainable models

Easily share and reuse concepts

Project Moab – https://aka.ms/moab

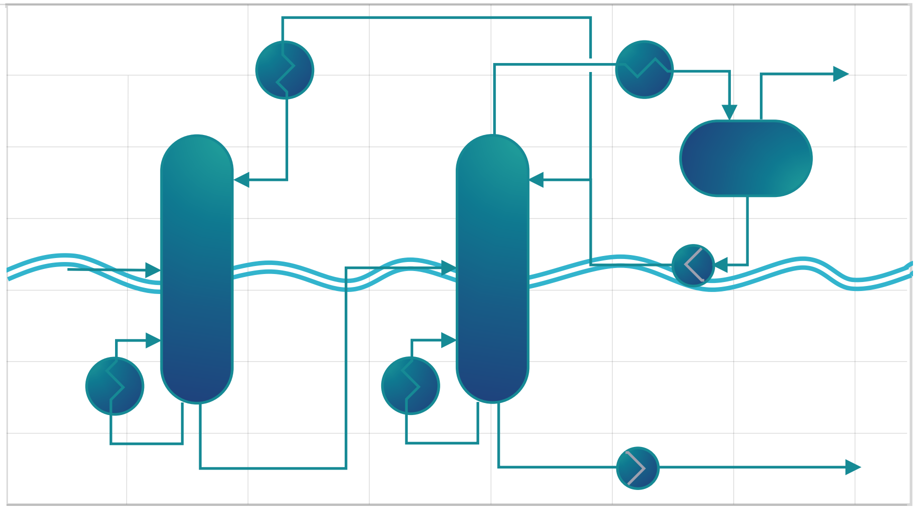
Autonomous Systems Online Demos

https://aidemos.microsoft.com/machineteaching

Machine Calibration	Smart Buildings	Motion Control
		

Microsoft Bonsai and AVEVA Dynamic Simulation for the Autonomous Plant

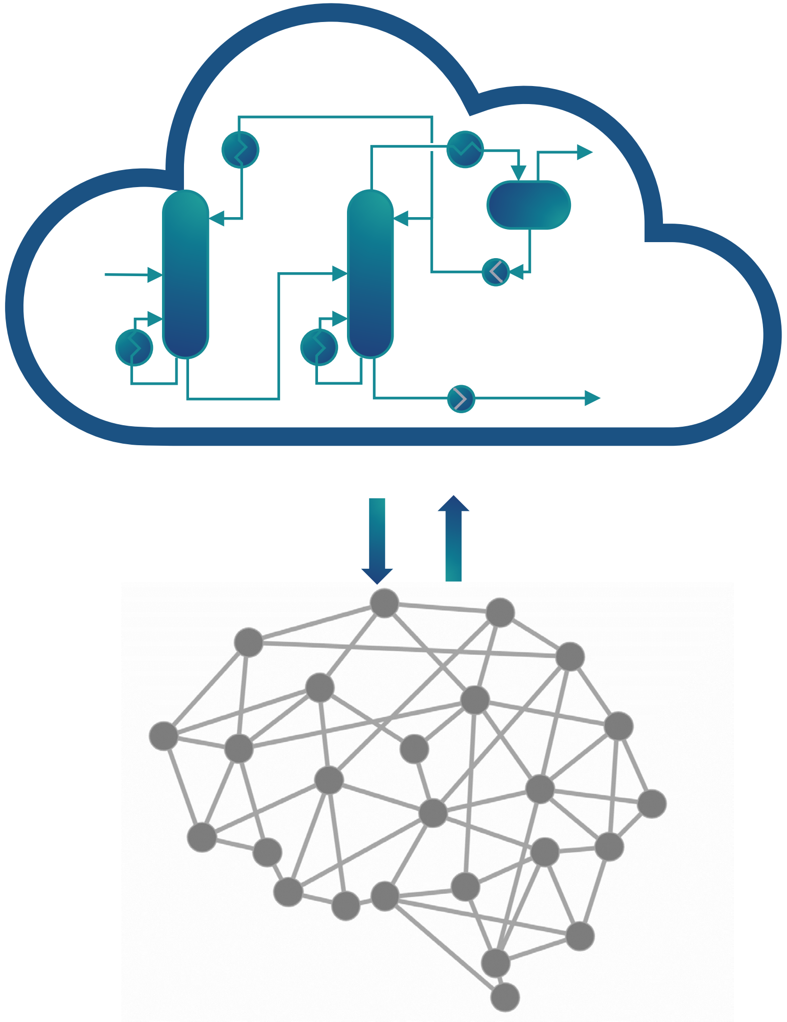
Problem Statement



The plant is changing feed weekly

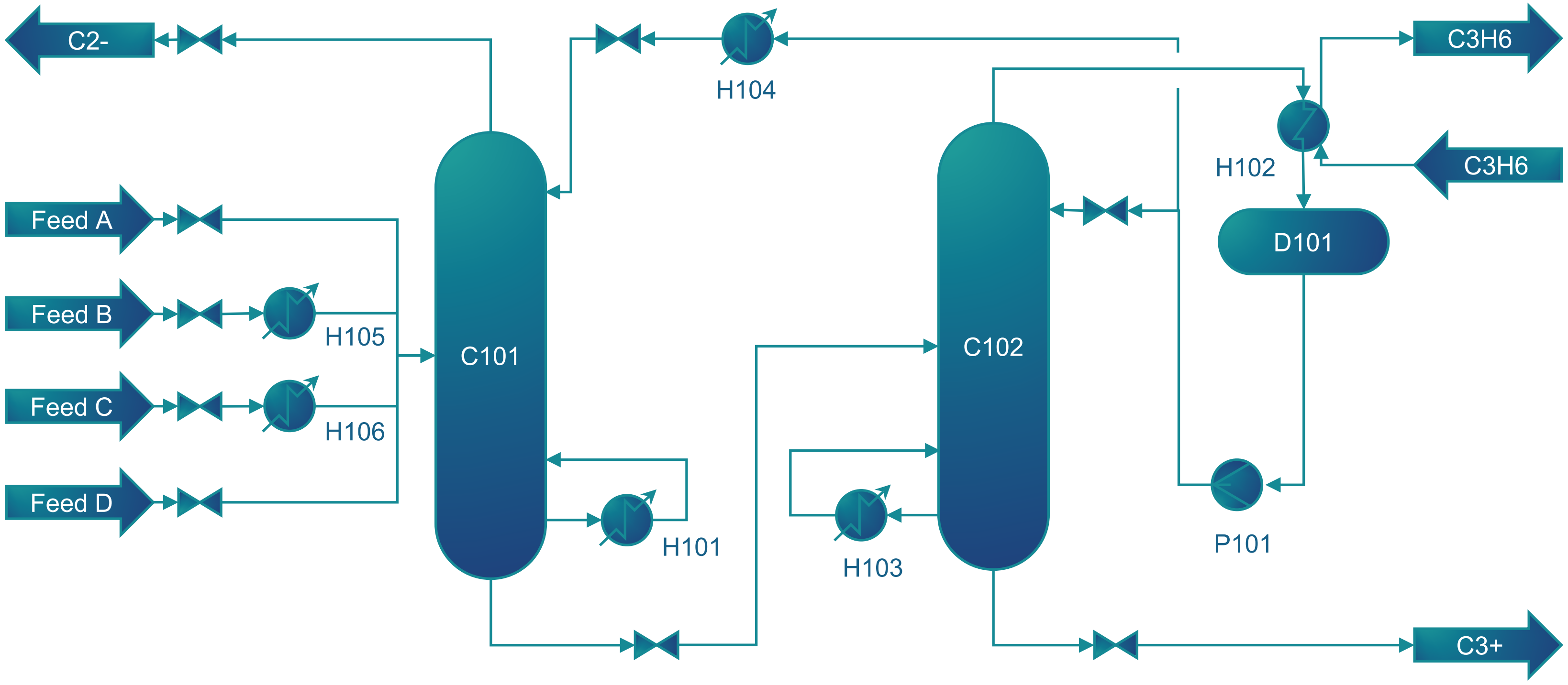
It takes the operators 8 hours to re-stabilize the plant

Several days of production are lost every year



Bonsai Brain can be trained to optimize the operation using a digital replica of the plant in the cloud

Process Description and Problem Definition



This distillation unit separates the raw gas and raw condensate feed streams into a light gas (C2-) and a heavier liquid (C3+) outlet. Column C101 operates as an absorber in the upper part and stripper in the lower part; column C102 works as a normal rectification column.

Initial Change

- FC Raw Condensates Feed

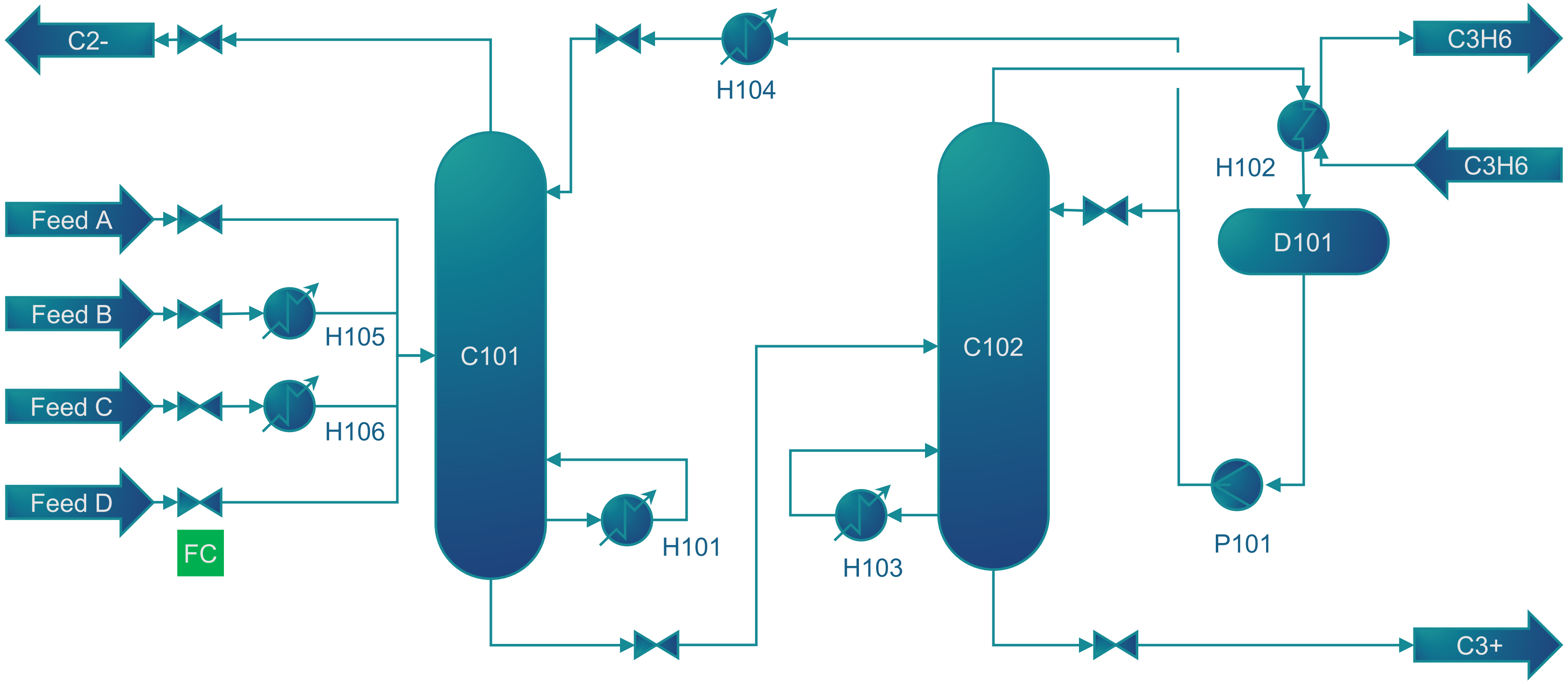
Action Space

- FC C102 reflux flow controller (set point)
- FC C101 bottom flow controller (set point)
- TC C102 temperature controller (set point)

State Space

- TT C101 top temperature
- TT C101 bottom temperature
- PT C101 top pressure
- AT C101 top C3 concentration
- AT C101 top C2 concentration
- LT C101 level
- TT C102 top temperature
- TT C102 bottom temperature
- PT C102 top pressure
- AT C102 top C3 concentration
- AT C102 bottom C2 concentration
- LT C102 level
- LT H102 level
- LT D101 level

Process Description and Problem Definition



The objective is to stabilize the unit after a change in the raw feed condensate (Feed D) in the lowest time possible.

Initial Change

Raw Condensates Feed

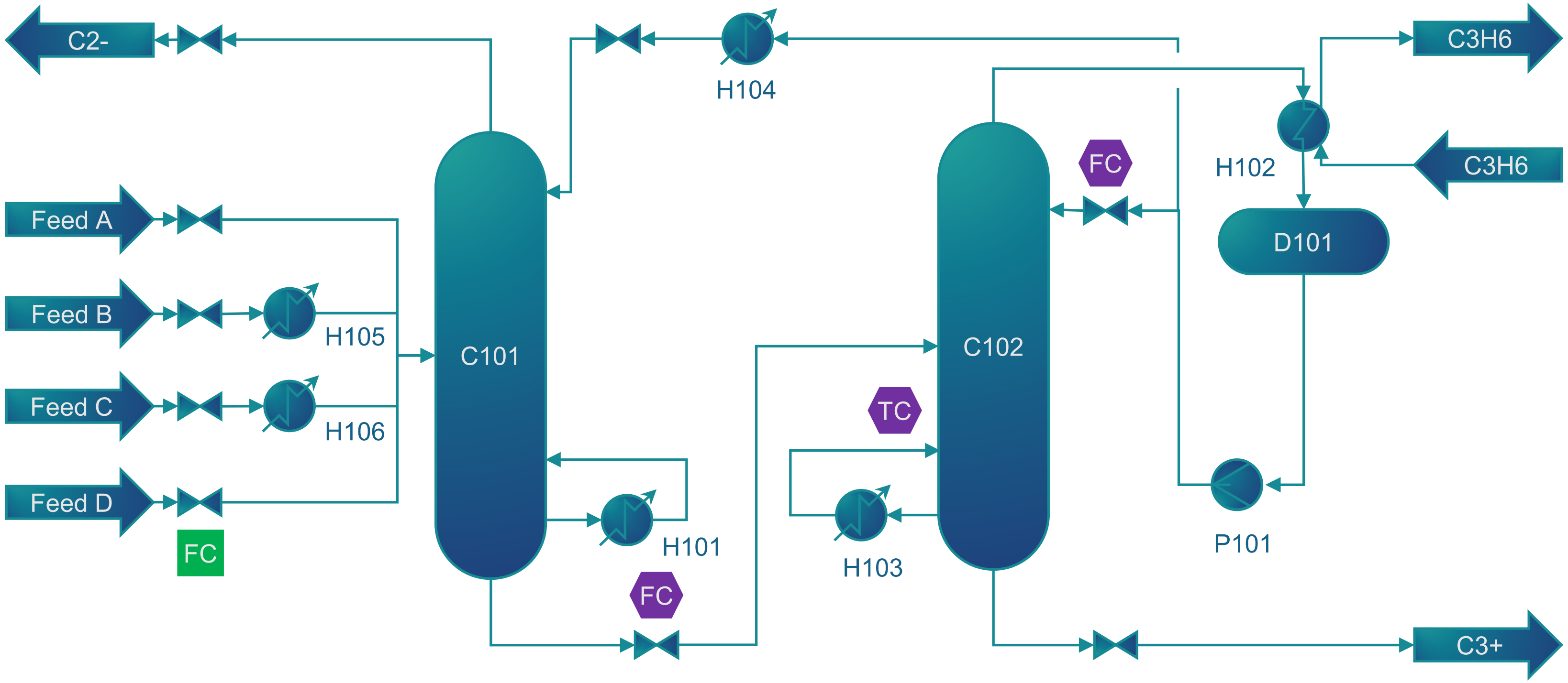
Action Space

- FC C102 reflux flow controller (set point)
- FC C101 bottom flow controller (set point)
- TC C102 temperature controller (set point)

State Space

- TT C101 top temperature
- TT C101 bottom temperature
- PT C101 top pressure
- AT C101 top C3 concentration
- AT C101 top C2 concentration
- LT C101 level
- TT C102 top temperature
- TT C102 bottom temperature
- PT C102 top pressure
- AT C102 top C3 concentration
- AT C102 bottom C2 concentration
- LT C102 level
- LT H102 level
- LT D101 level

Process Description and Problem Definition



Initial Change

Raw Condensates Feed

Action Space

C102 reflux flow controller (set point)

C101 bottom flow controller (set point)

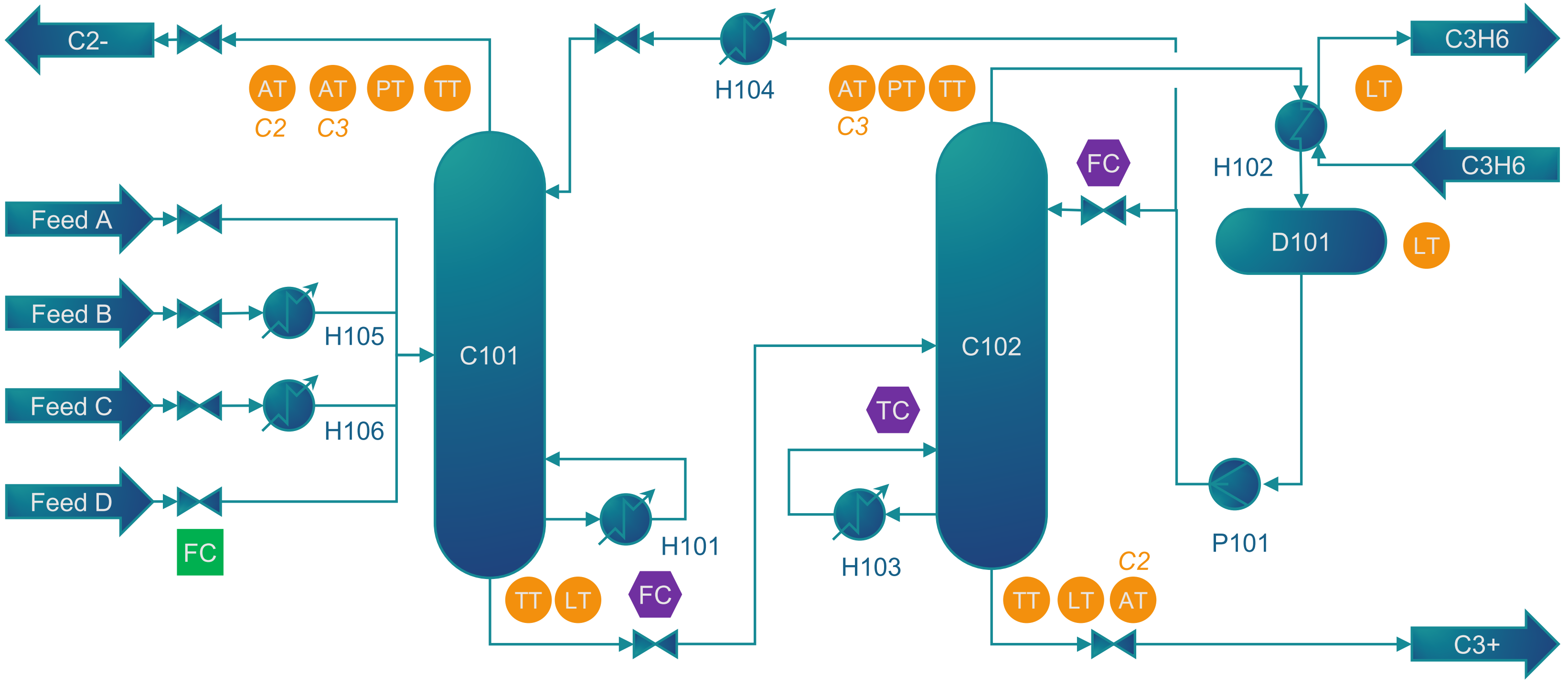
C102 temperature controller (set point)

State Space

- TT C101 top temperature
- TT C101 bottom temperature
- PT C101 top pressure
- AT C101 top C3 concentration
- AT C101 top C2 concentration
- LT C101 level
- TT C102 top temperature
- TT C102 bottom temperature
- PT C102 top pressure
- AT C102 top C3 concentration
- AT C102 bottom C2 concentration
- LT C102 level
- LT H102 level
- LT D101 level

The AI agent can change the setpoint of the C101 bottom flow rate, C102 reflux flow rate and C102 temperature.

Process Description and Problem Definition



Initial Change

Raw Condensates Feed

Action Space

C102 reflux flow controller (set point)

C101 bottom flow controller (set point)

C102 temperature controller (set point)

Observation Space

C101 top temperature

C101 bottom temperature

C101 top pressure

C101 top C3 concentration

C101 top C2 concentration

C101 level

C102 top temperature

C102 bottom temperature

C102 top pressure

C102 top C3 concentration

C102 bottom C2 concentration

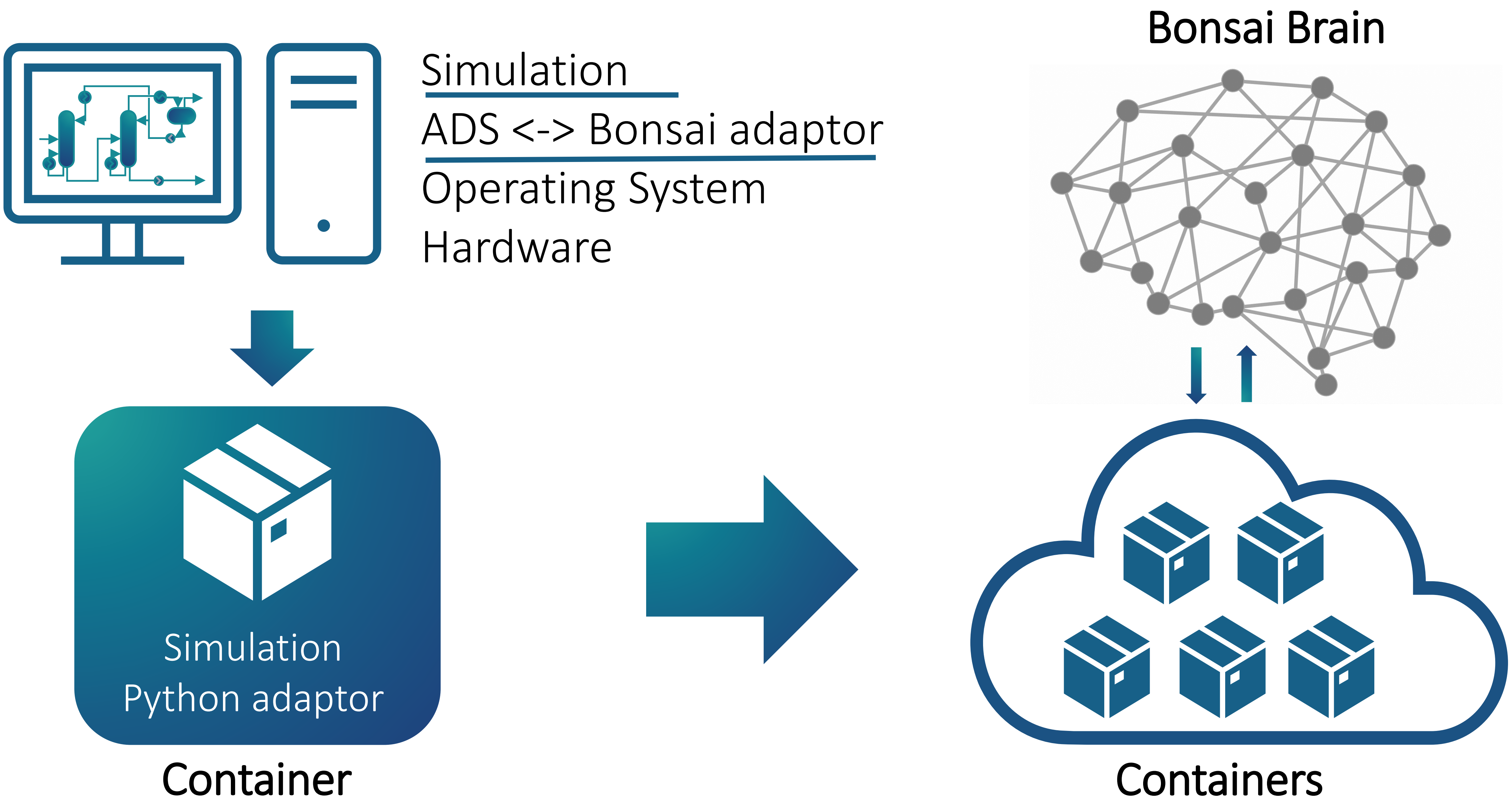
C102 level

H102 level

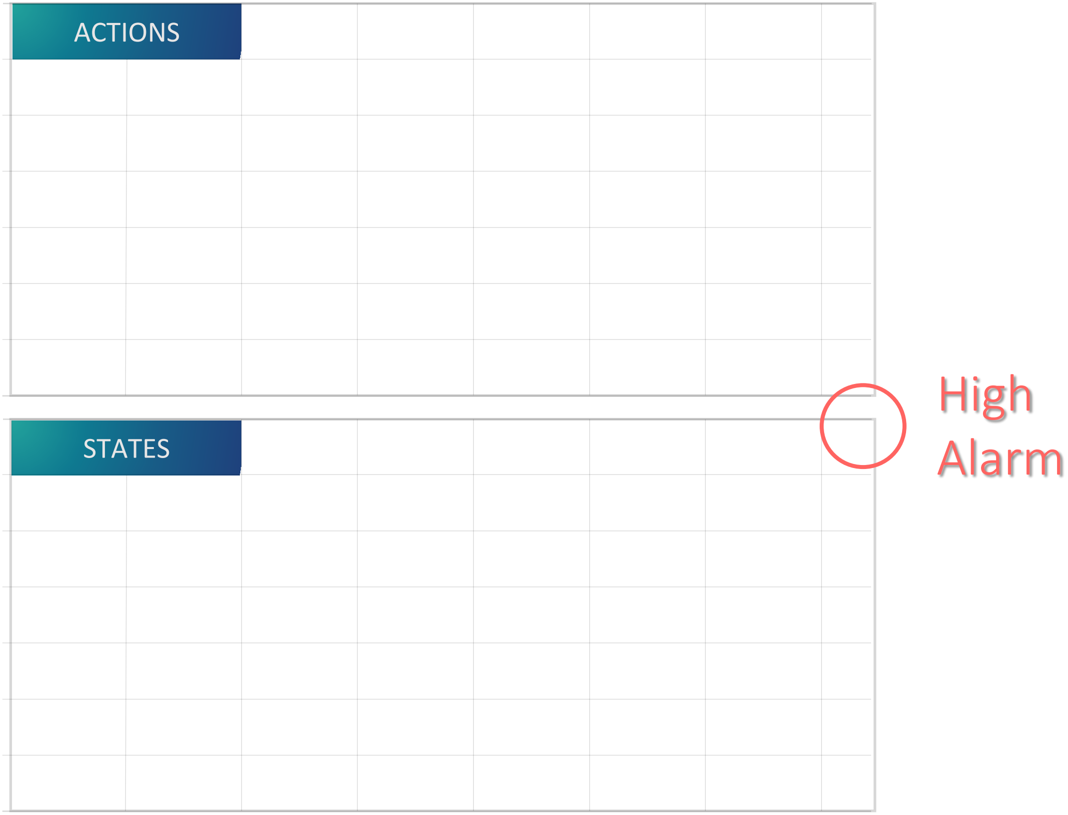
D101 level

The episode is considered successfully completed when all 14 key process variables are stabilized (fluctuations drop below 2% of their range) and no alarm is triggered during the operation.

Containerization and the Cloud

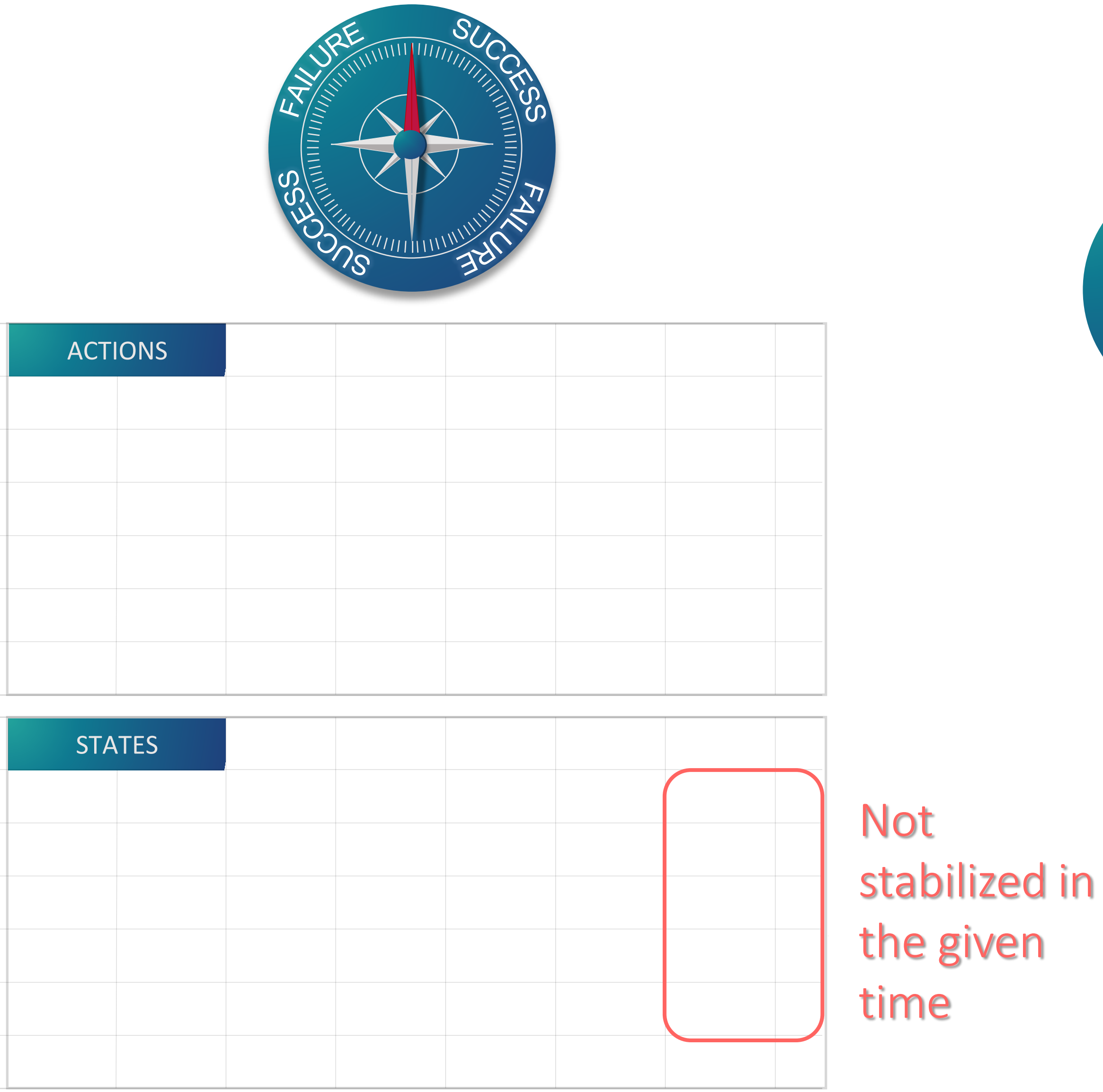


Training Bonsai



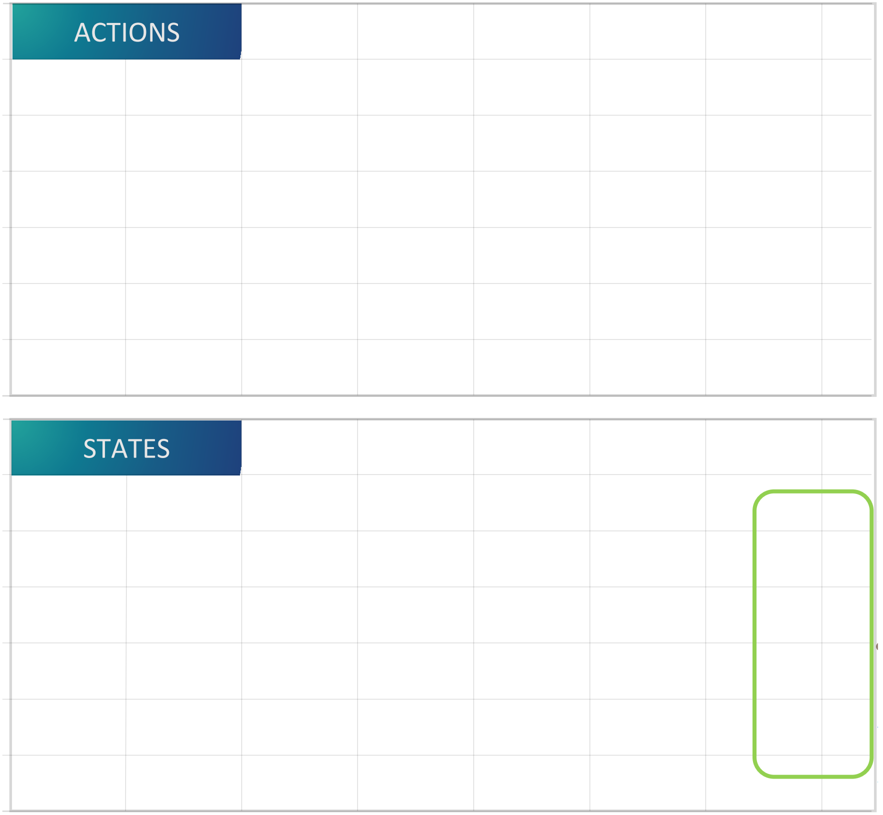
The episode is considered failed when one of the 14 key process variables hits a high or low alarm during the operation.

Training Bonsai



The episode is considered failed when the process is not reaching stability within the maximum allowed duration.

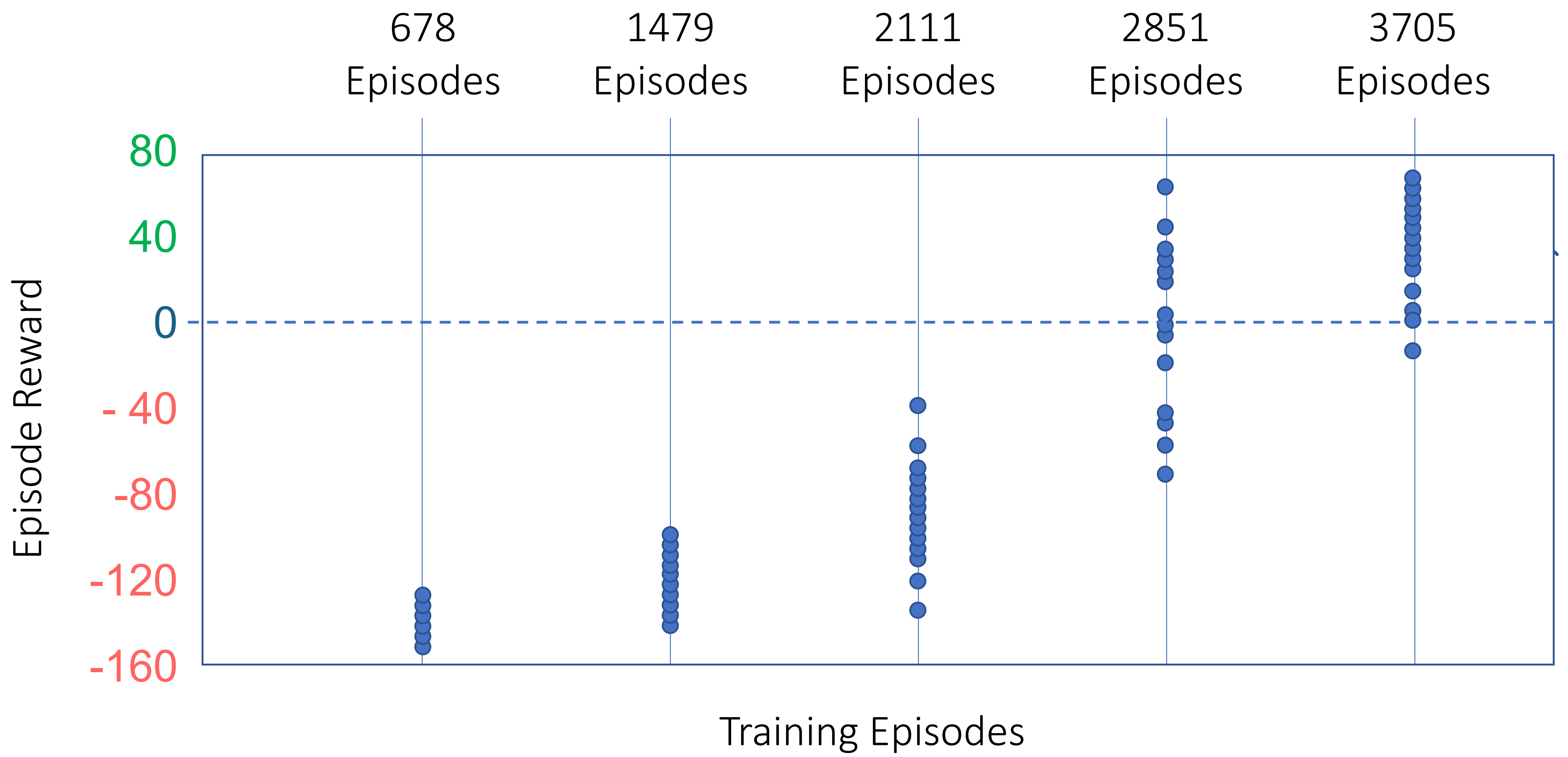
Training Bonsai



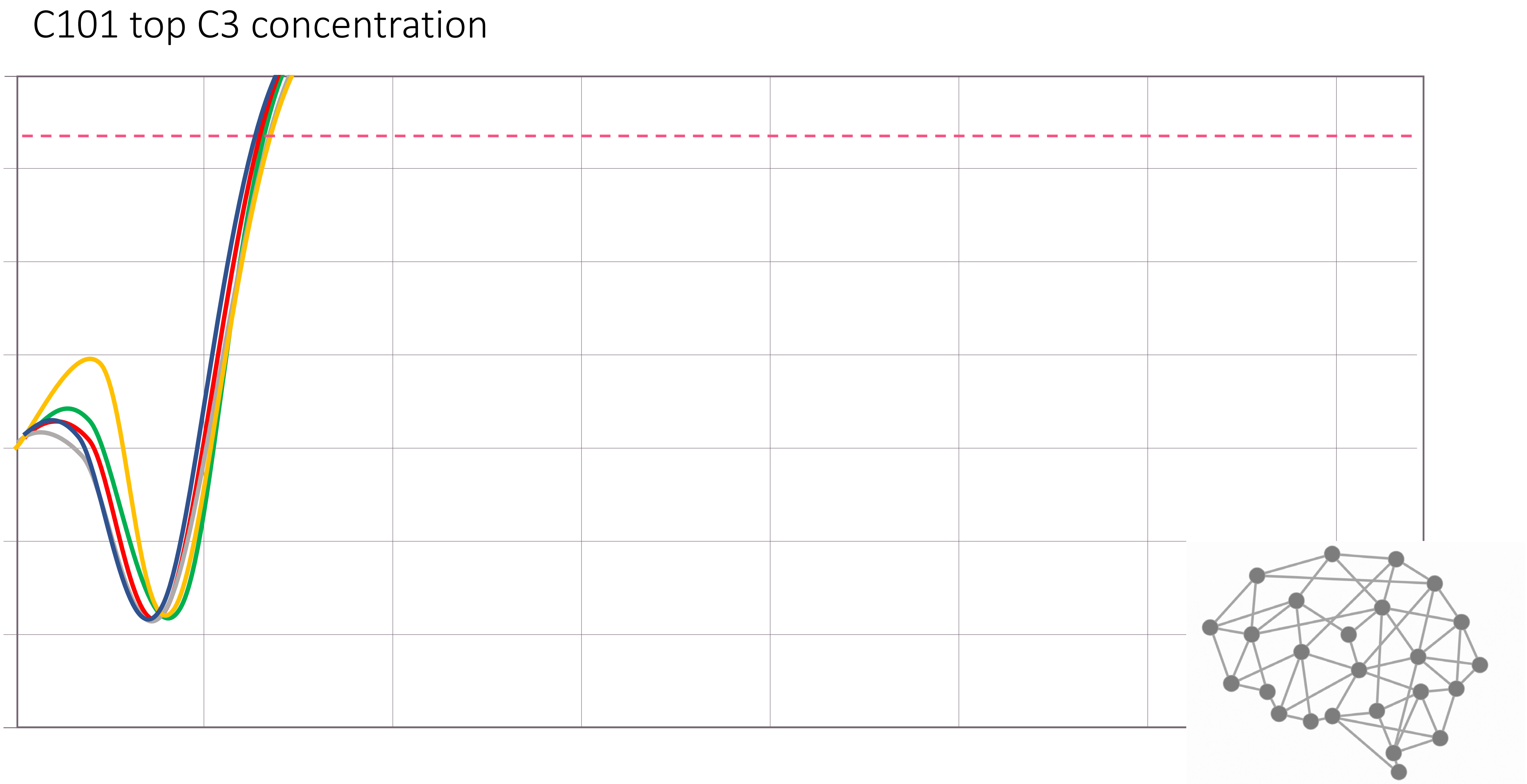
All variables are stable

The episode is considered successful when all 14 key process variables are stabilized without triggering any alarms.

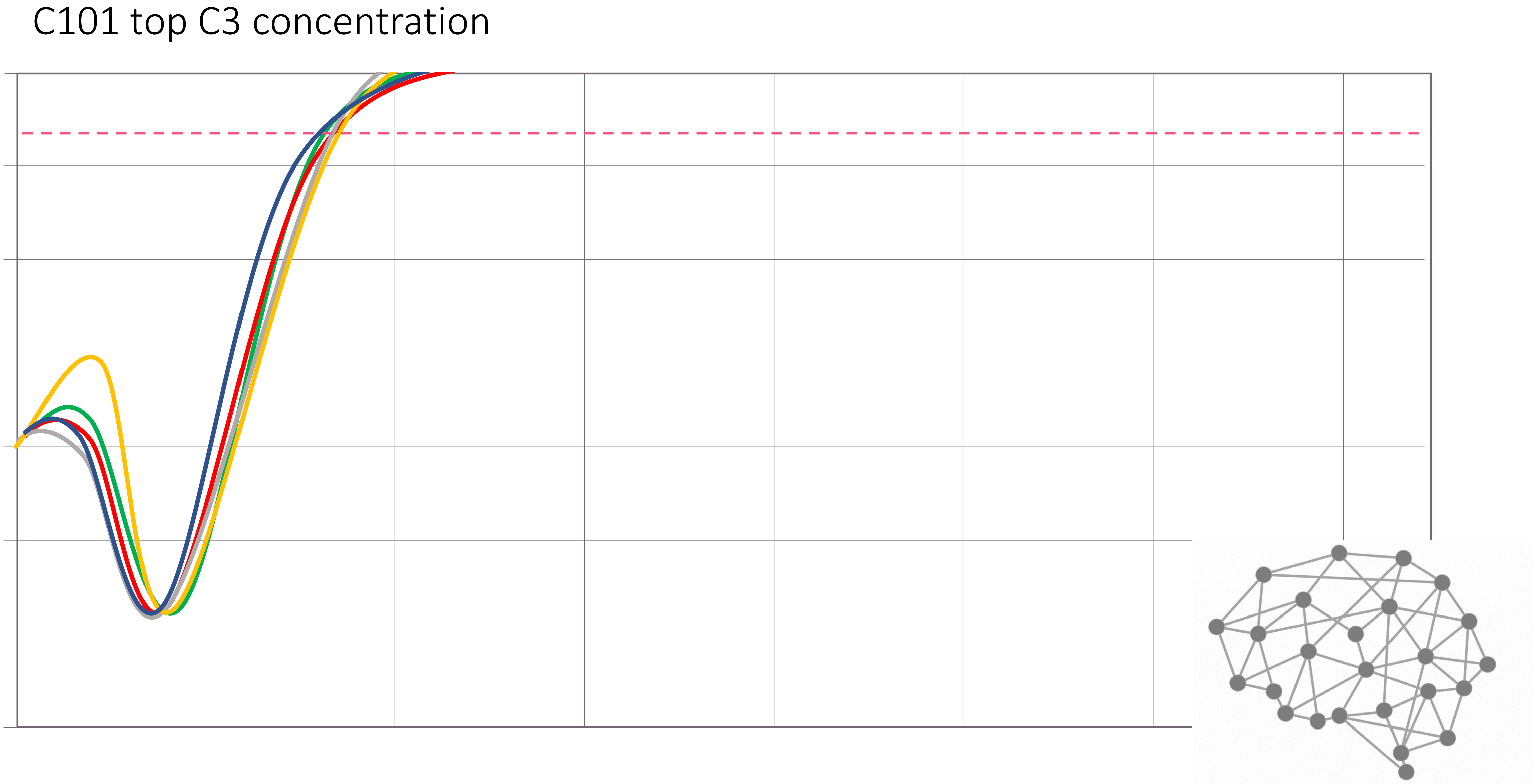
Learning Results



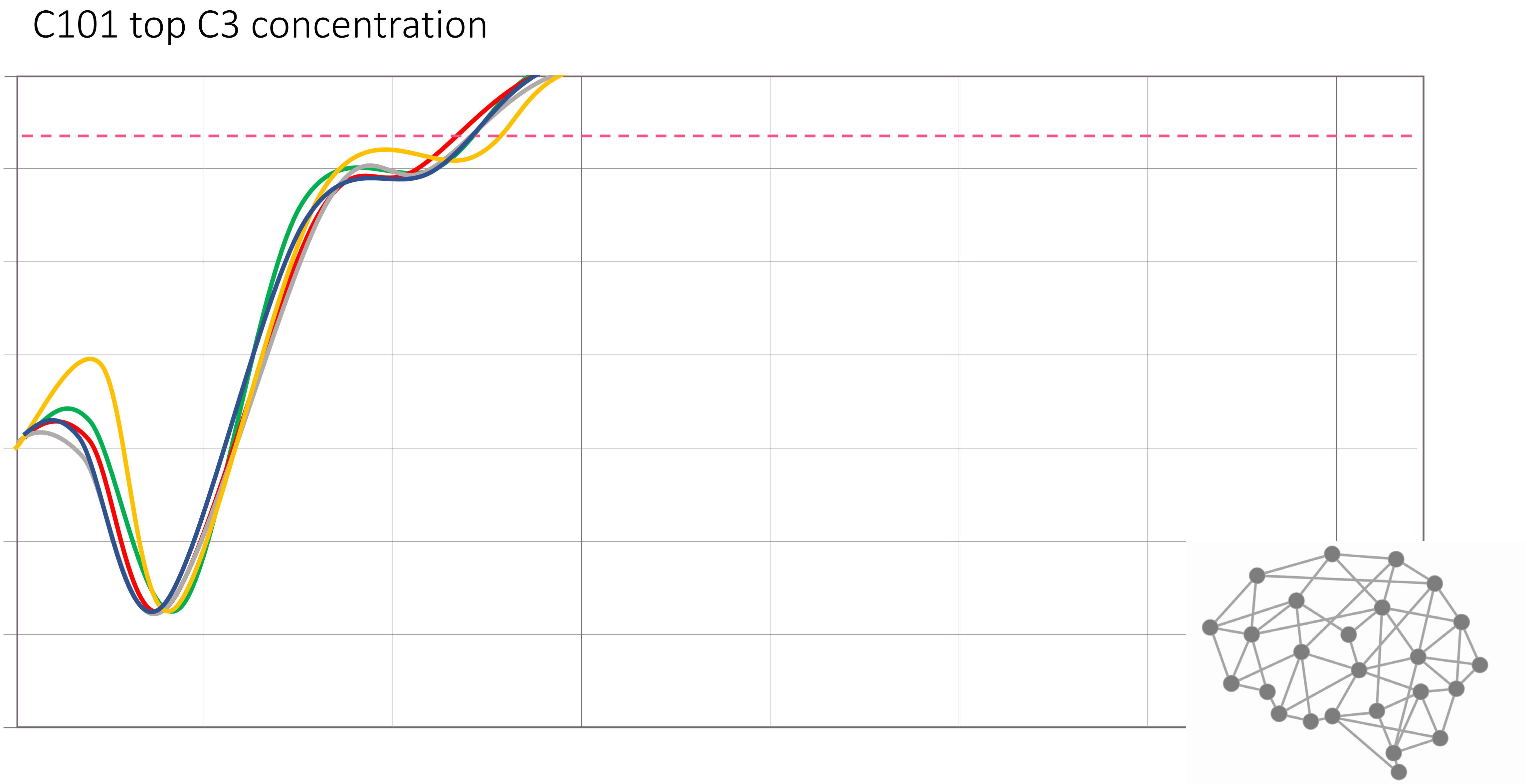
135 Episodes



678 Episodes

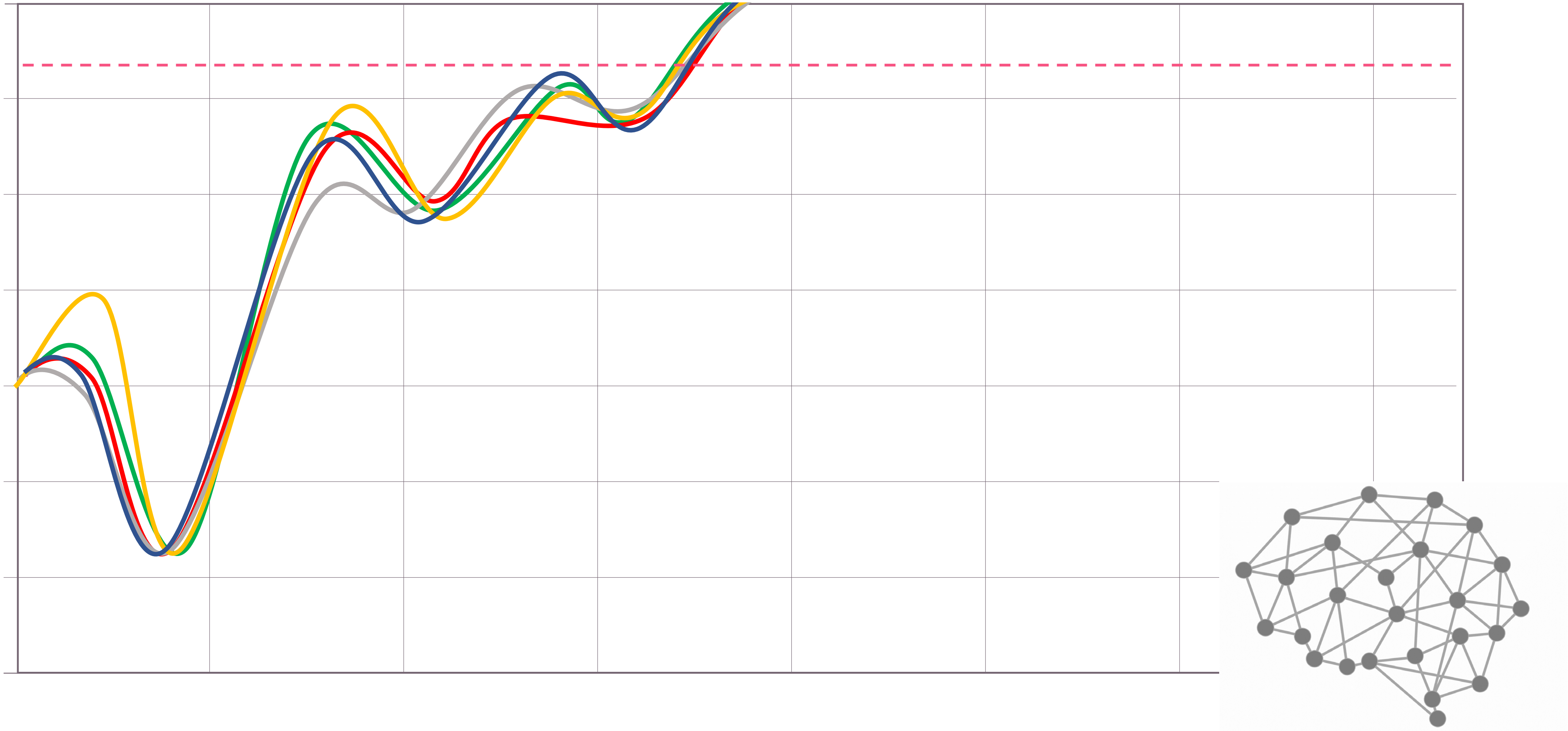


1479 Episodes

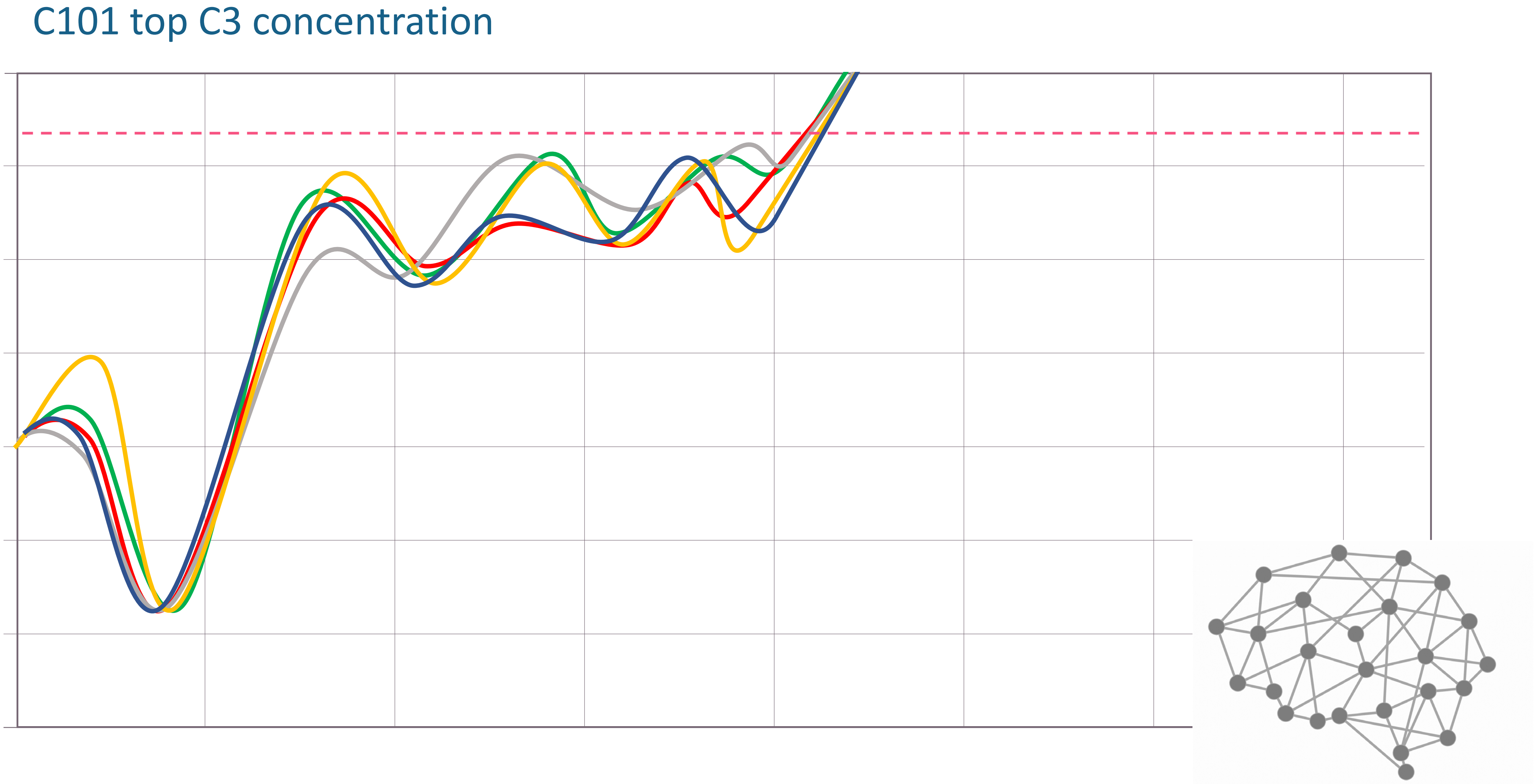


2111 Episodes

C101 top C3 concentration

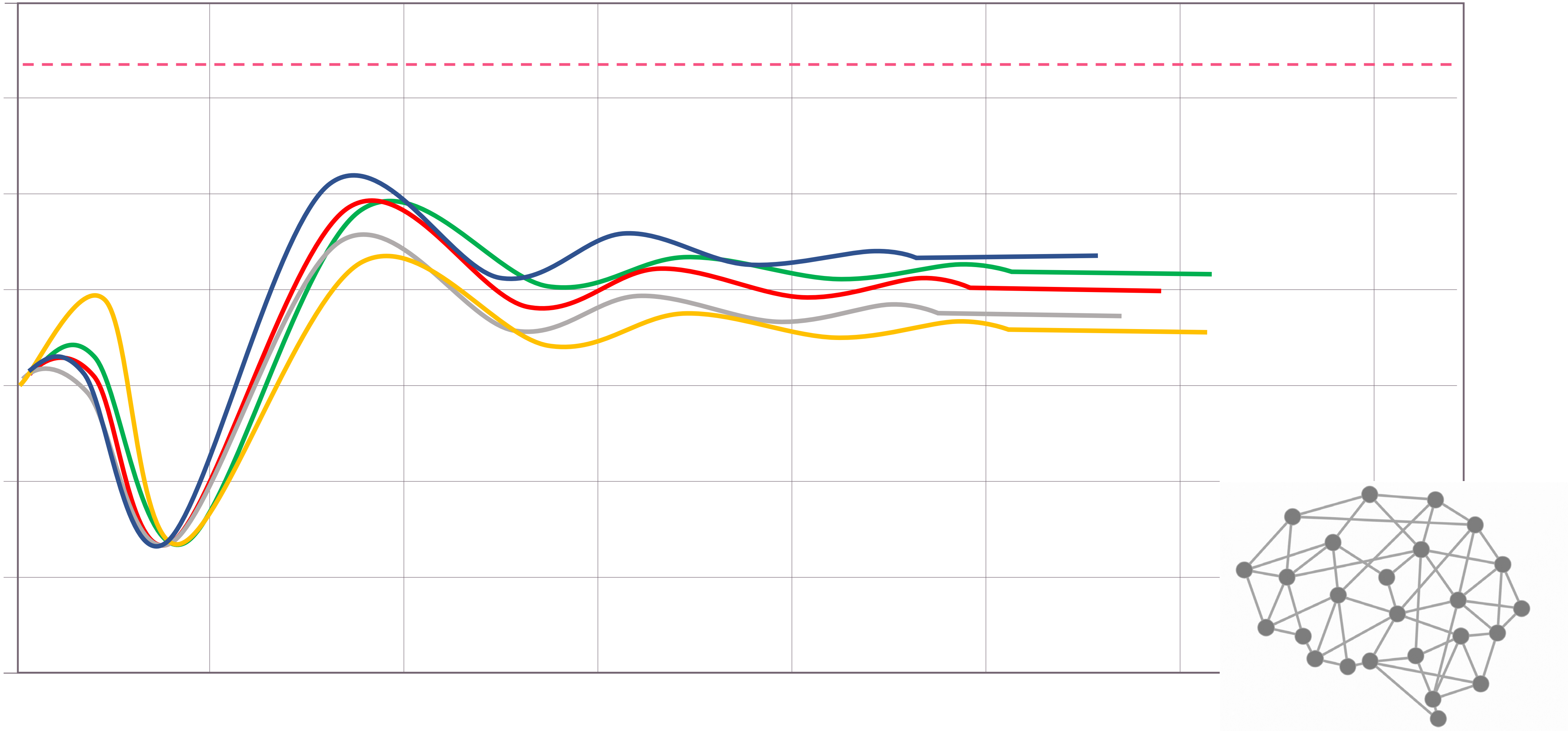


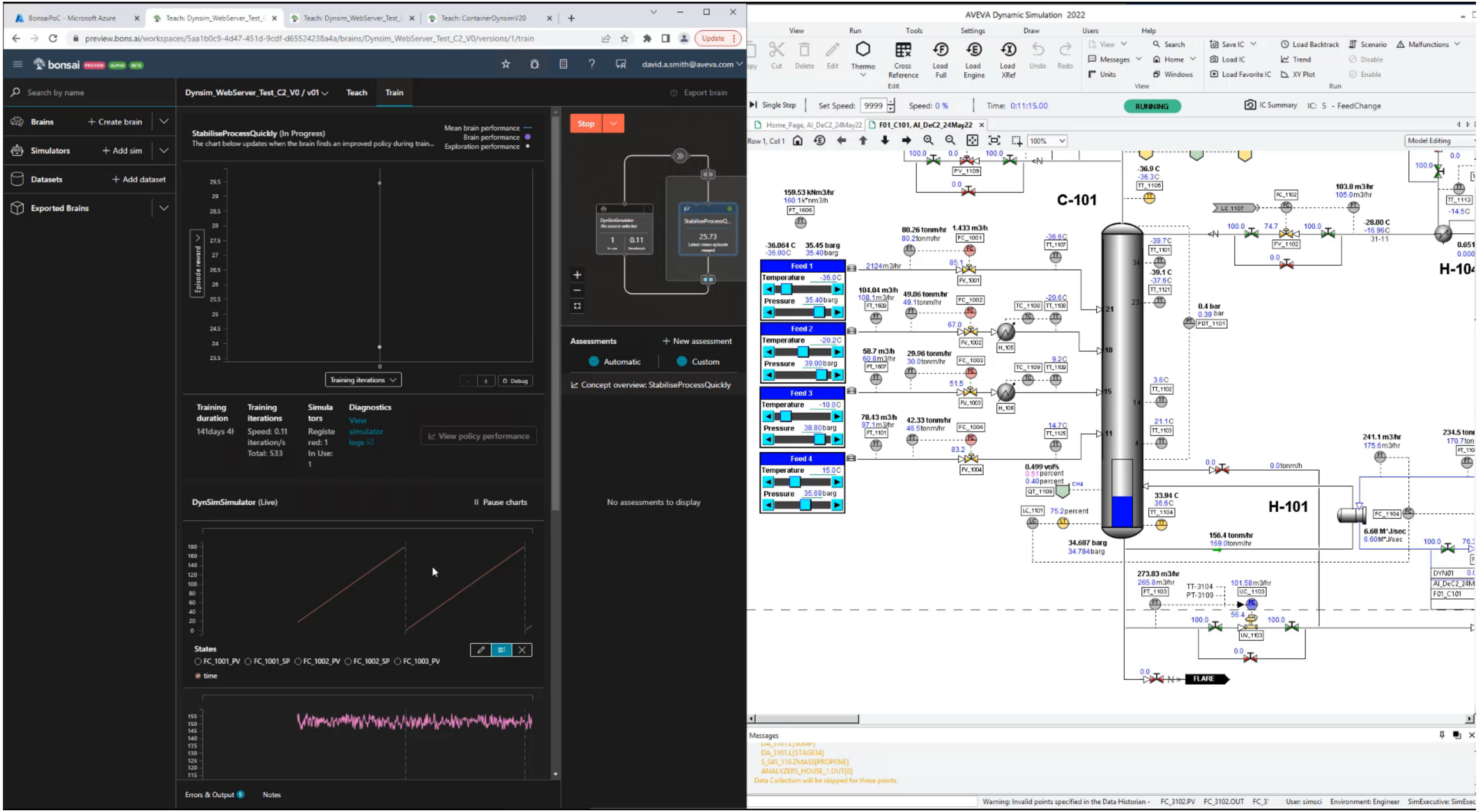
2851 Episodes



3705 Episodes

C101 top C3 concentration



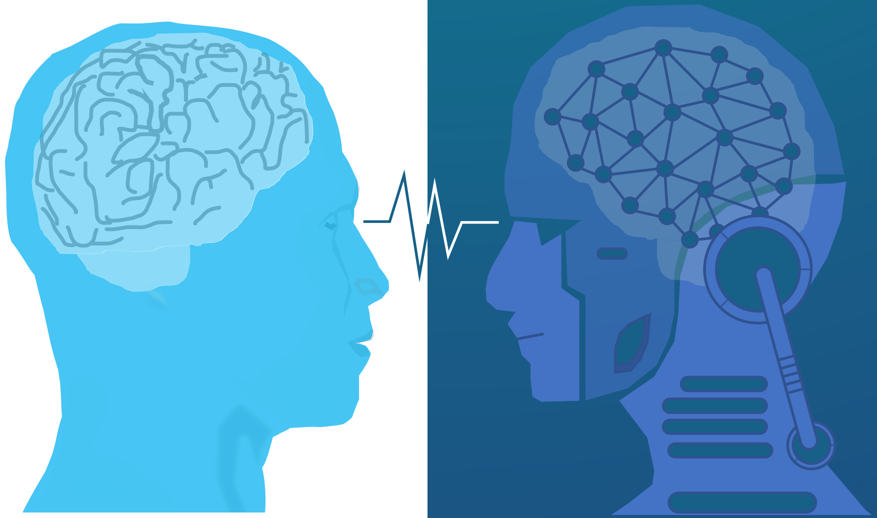

BonsaiPoC - Microsoft Azure
Teach: Dynsim_WebServer_Test_C
Teach: Dynsim_WebServer_Test_C
Teach: ContainerDynsimV20
preview.bons.ai/workspaces/5aa1b0c9-4d47-451d-9cdf-d65524238a4a/brains/Dynsim_WebServer_Test_C2_V0/versions/1/train
bonsai
david.a.smith@aveva.com
Search by name
Brains
+ Create brain
Simulators
+ Add sim
Datasets
+ Add dataset
Exported Brains
Dynsim_WebServer_Test_C2_V0 / v01
Teach
Train
Export brain
StabiliseProcessQuickly (In Progress)
The chart below updates when the brain finds an improved policy during train...
Mean brain performance
Brain performance
Exploration performance
Episode reward
Training iterations
Debug
Stop
DynSimSimulator
StabiliseProcessQ...
25.73
Assessments
+ New assessment
Automatic
Custom
Concept overview: StabiliseProcessQuickly
Training duration
141days 4h
Training iterations
Speed: 0.11 iteration/s
Total: 533
Simulators
Registered: 1
In Use: 1
Diagnostics
View simulator logs
View policy performance
DynSimSimulator (Live)
Pause charts
No assessments to display
States
FC_1001_PV
FC_1001_SP
FC_1002_PV
FC_1002_SP
FC_1003_PV
time
Errors & Output
Notes
AVEVA Dynamic Simulation 2022
View
Run
Tools
Settings
Draw
Users
Help
Cut
Delete
Edit
Thermo
Cross Reference
Load Full
Load Engine
Load XRef
Undo
Redo
Messages
Units
Search
Home
Windows
Save IC
Load IC
Load Favorite IC
Load Backtrack
Trend
XY Plot
Scenario
Disable
Enable
Malfunctions
Single Step
Set Speed: 9999
Speed: 0 %
Time: 0:11:15.00
RUNNING
IC Summary
IC: 5 - FeedChange
Home_Page_AI_DeC2_24May22
F01_C101_AI_DeC2_24May22
Row 1, Col 1
100%
Model Editing
C-101
H-101
Feed 1
Feed 2
Feed 3
Feed 4
Temperature
Pressure
FLARE
Messages
DA_3101.L[STAGE34]
S_04S_110.ZMASS[PROPENE]
ANALYZERS_HOUSE_1.OUT[0]
Data Collection will be skipped for these points.
Warning: Invalid points specified in the Data Historian -
FC_3102.PV
FC_3102.OUT
User: simsci
Environment: Engineer

Human

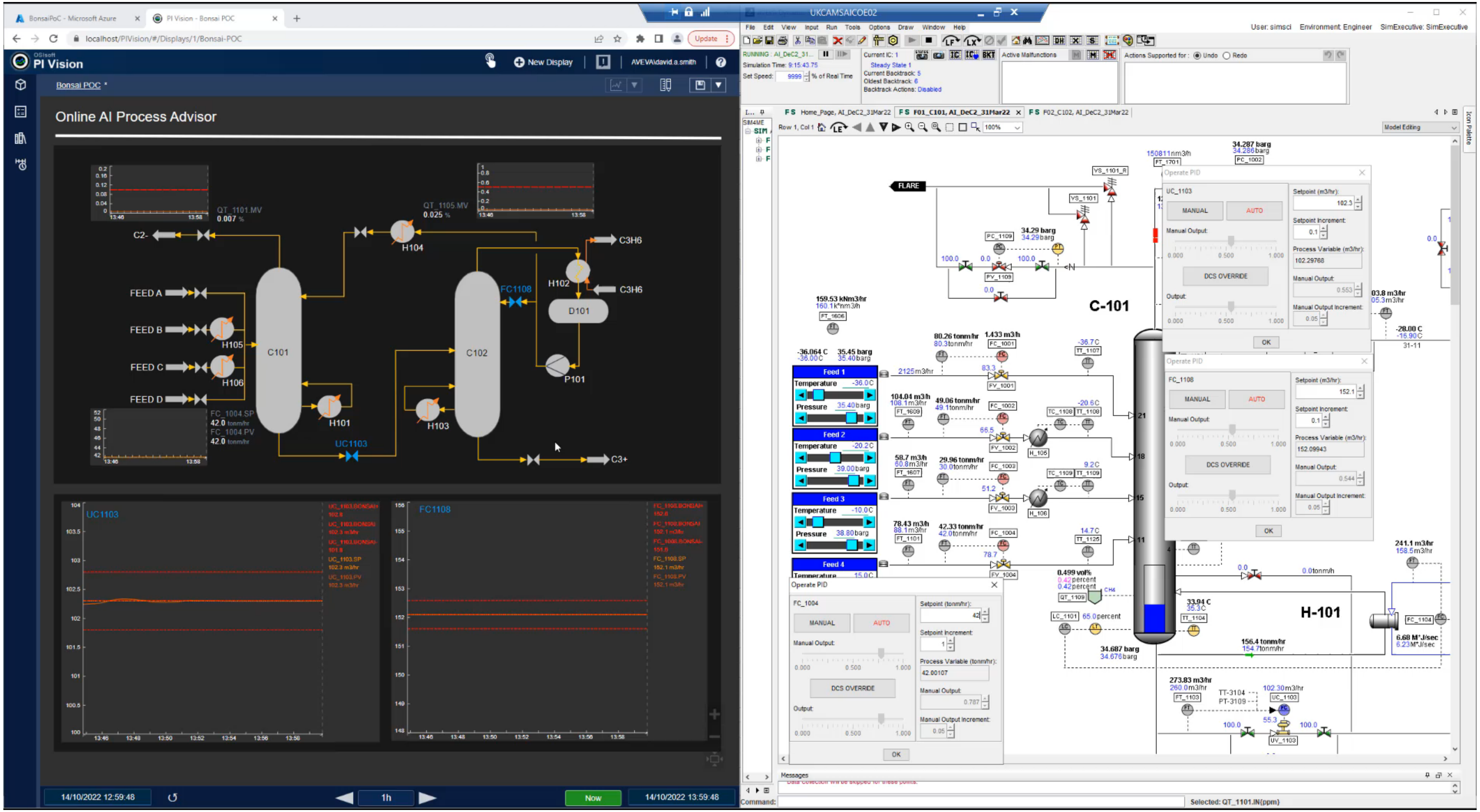
VS

AI Agent

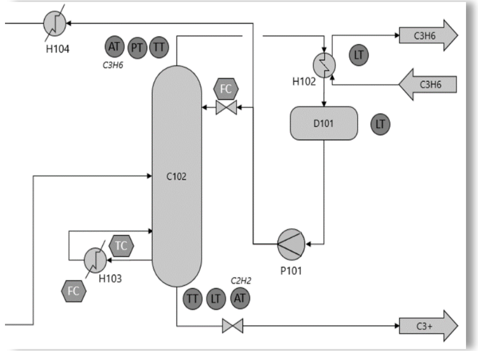
Human		AI Agent
07 28	Time to stabilize	HRS 04 MIN 06
03	Number of alarms	00



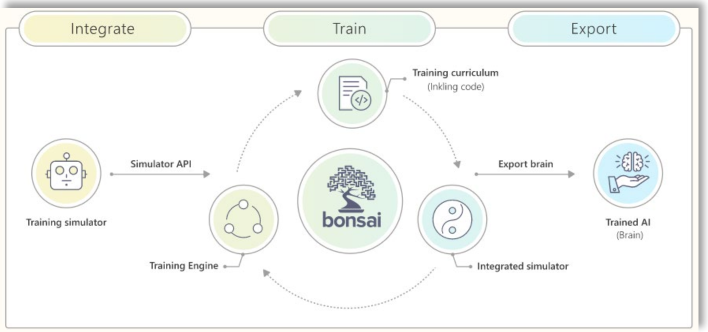
Deploy: Open Loop Advisor



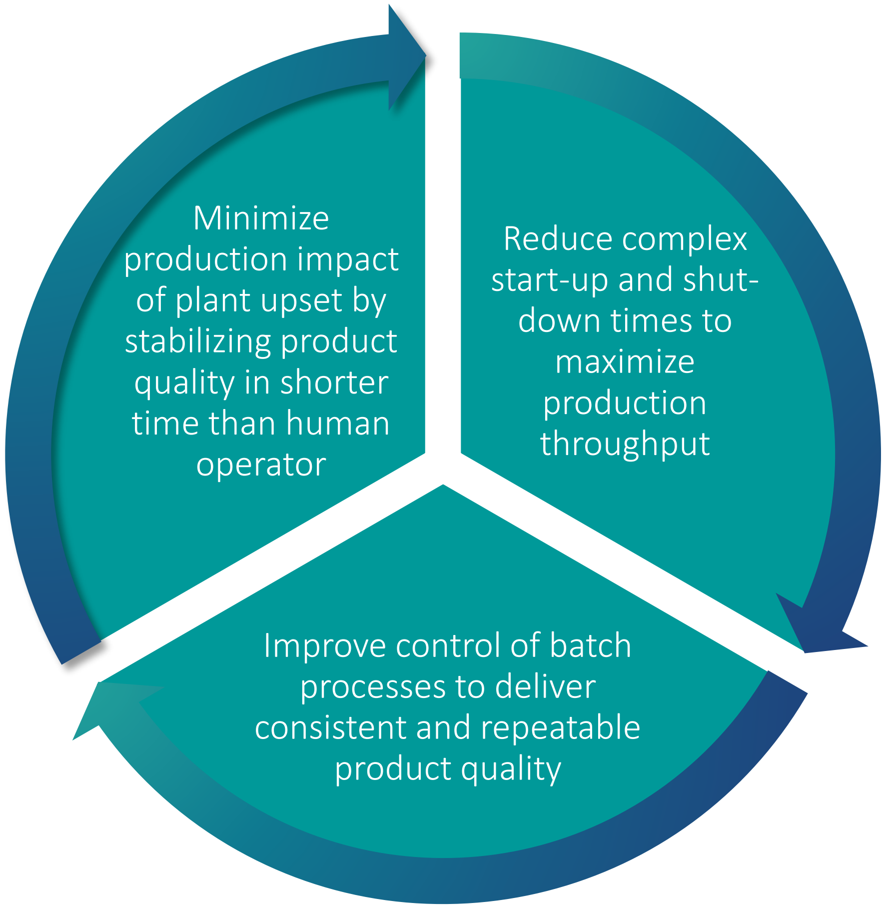
Conclusion



AVEVA Simulation



Reinforcement Learning Platform



Autonomous Operations for Process Plant

Questions?