HUMAN SYSTEMS LABORATORY

AI / ML-Enabled Digital Transformation of Japan's Process Industries

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2025/4/7 EU-JAPAN DIGITAL WEEK 2025（30min）

30 Emerging Technologies

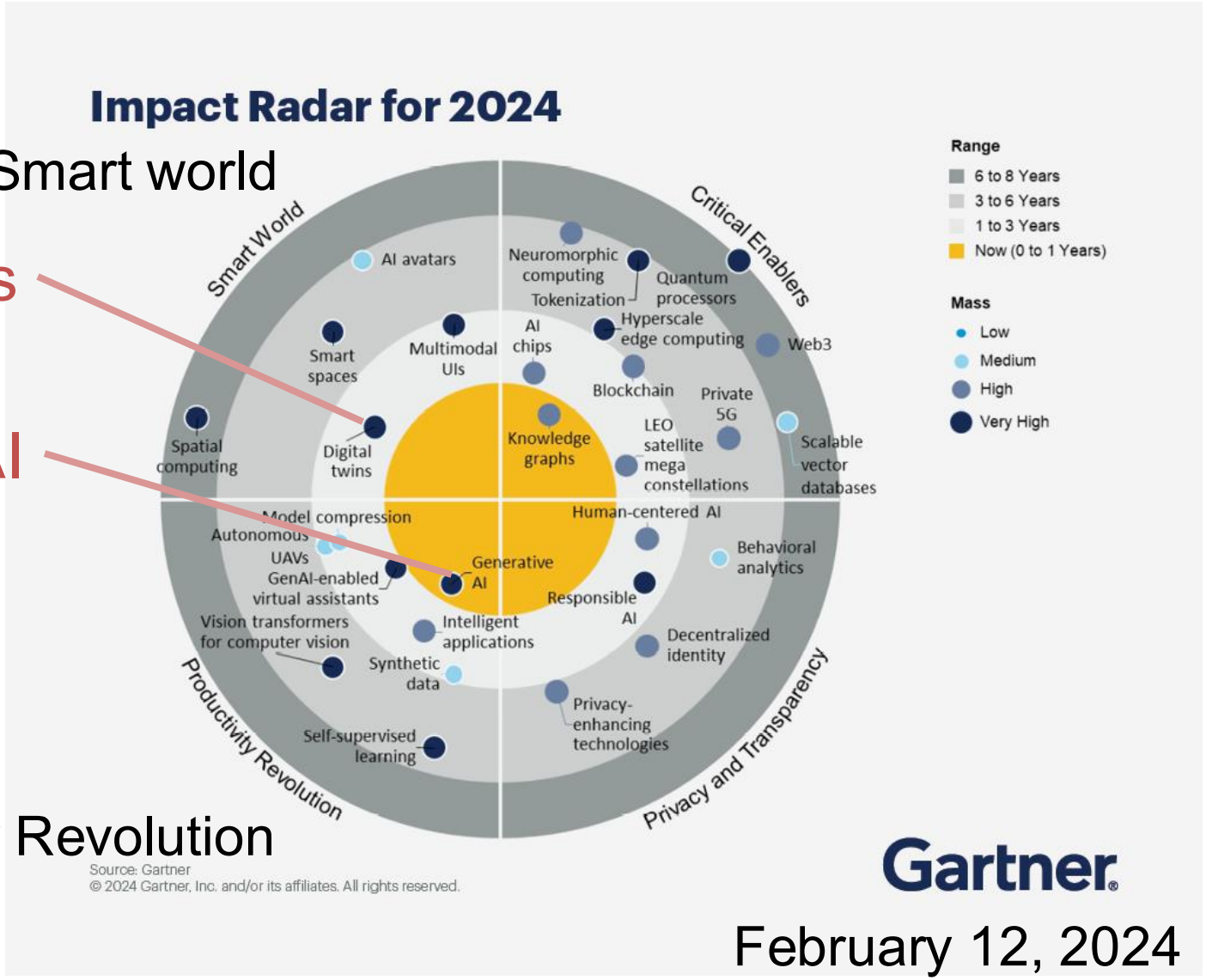
Technologies that, as of one year ago, was expected to be put into practical use within three years.

Smart world

Digital twins

Generative AI

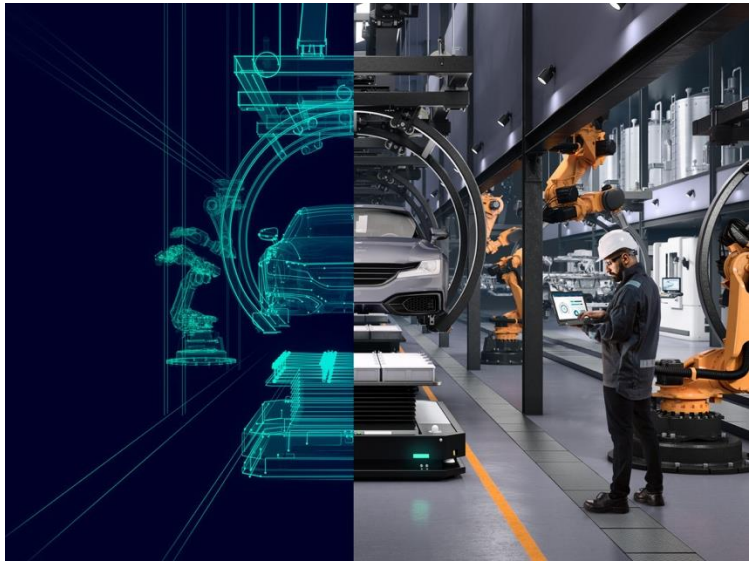
Productivity Revolution

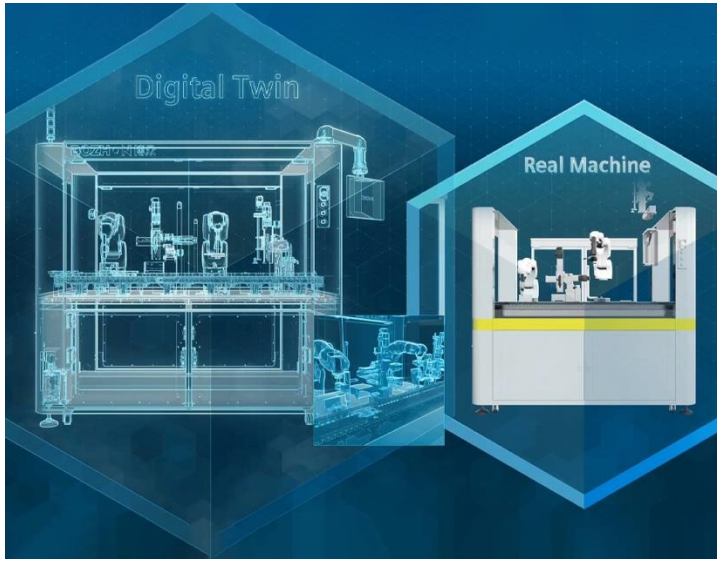


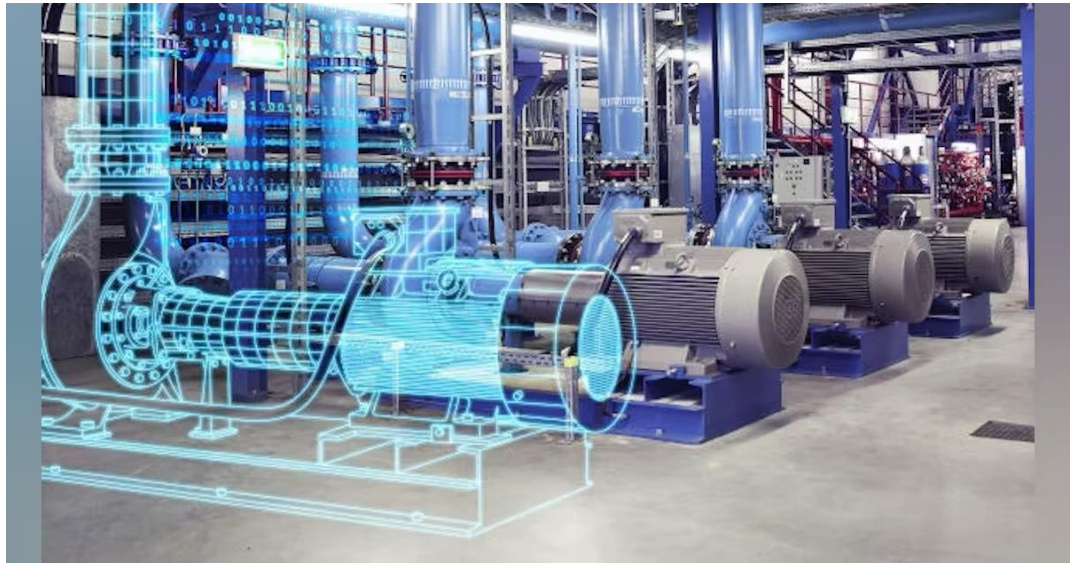
February 12, 2024

https://www.gartner.com/en/articles/30-emerging-technologies-that-will-guide-your-business-decisions

Digital twins in various fields

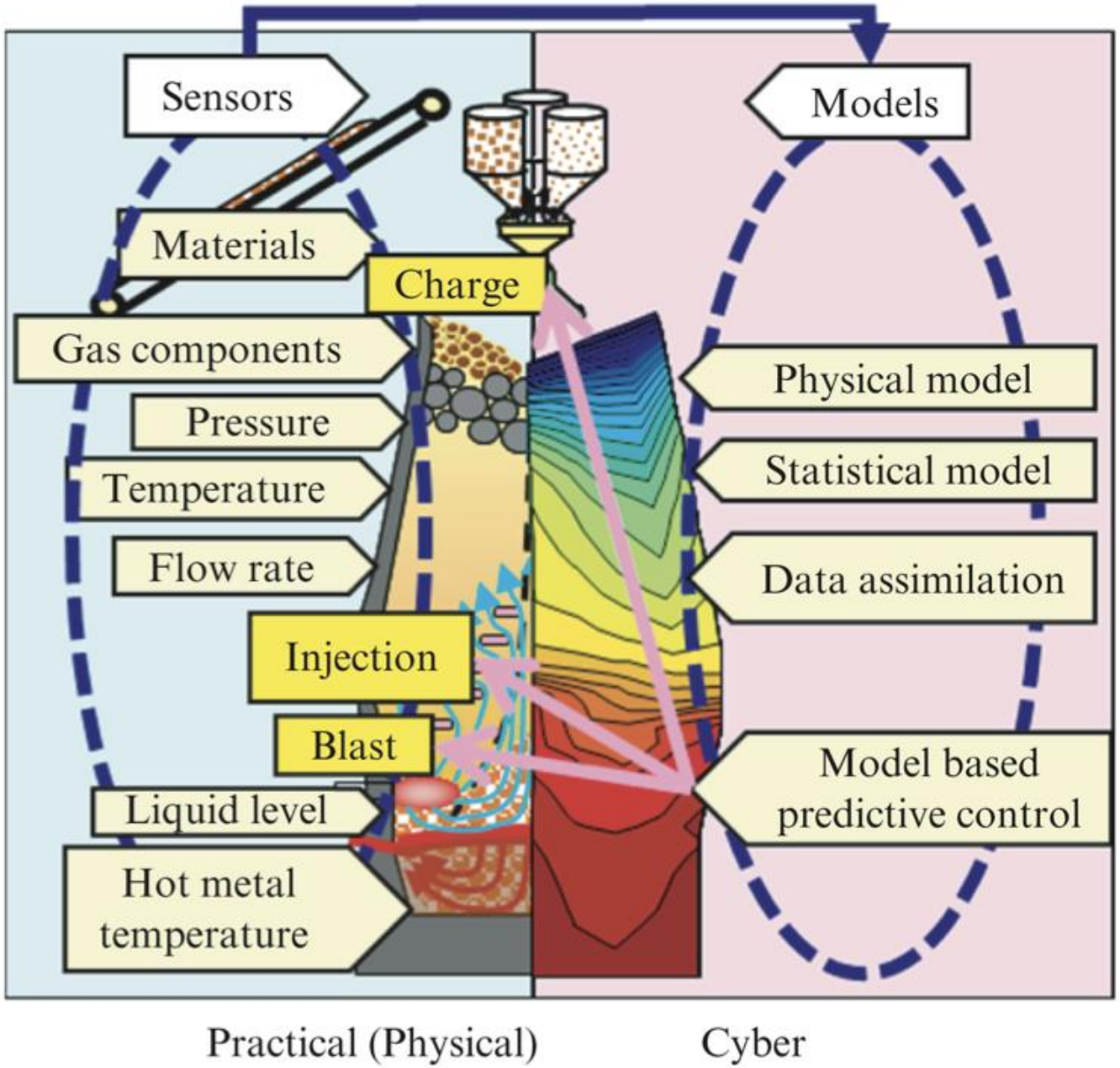




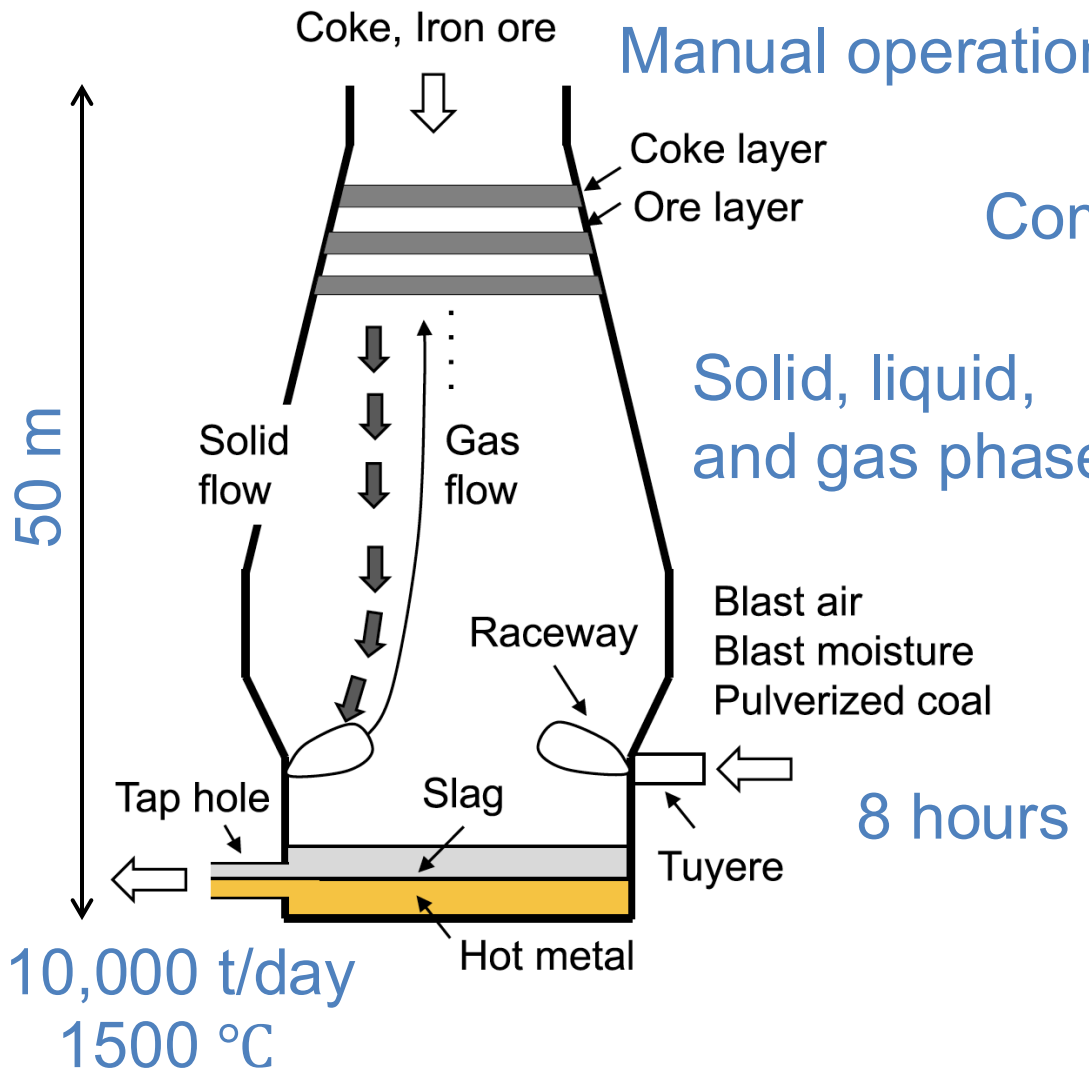


Blast Furnace CPS

Deployment of data science technologies across all blast furnaces at JFE Steelworks



Blast furnace: highly complex process



Manual operation

Complex reactions

Solid, liquid, and gas phases

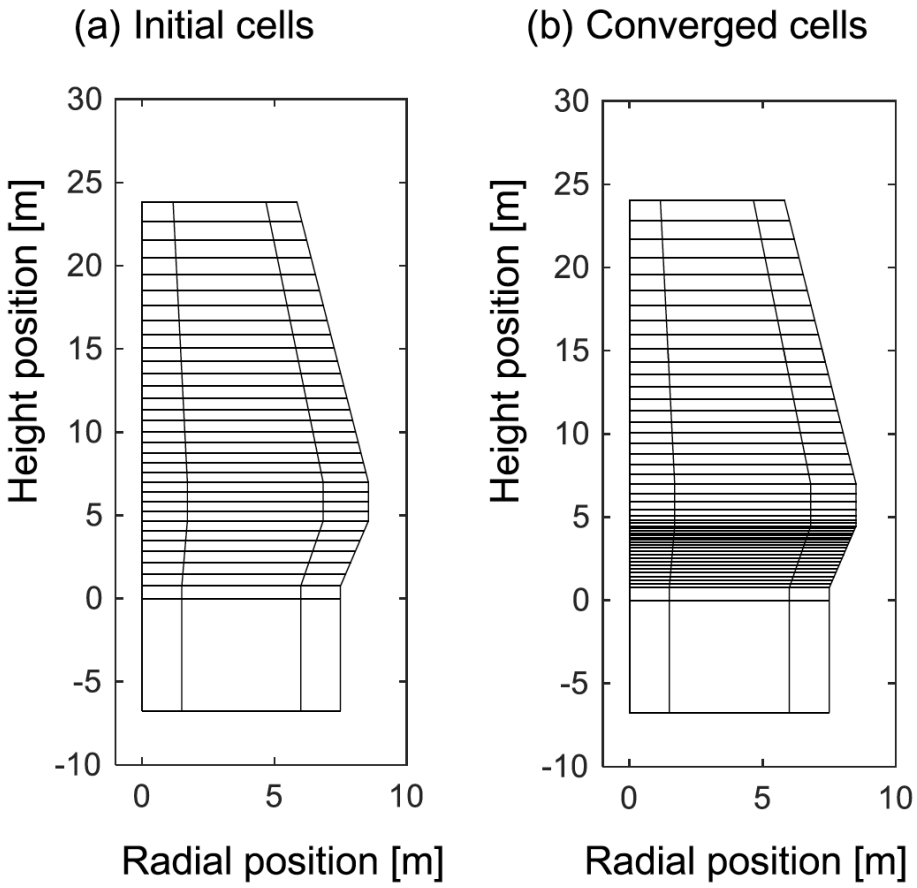
8 hours

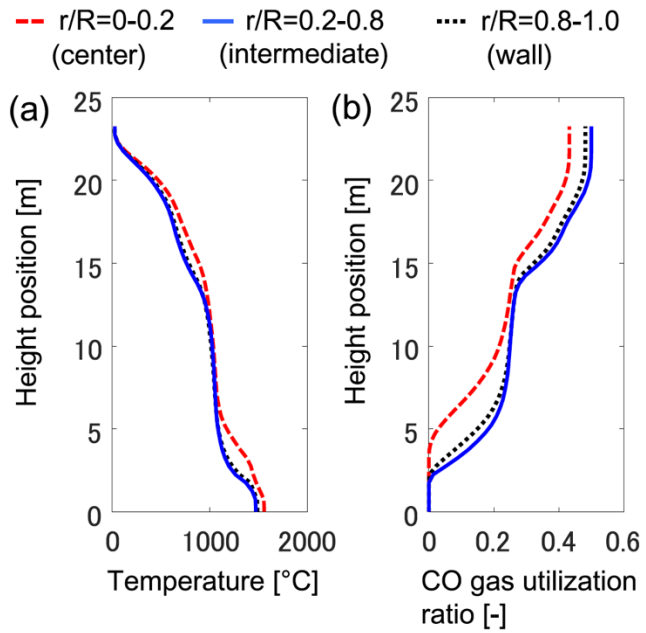
Symbol	Notes
R_1	$FeO_x + CO = FeO_{x-1} + CO_2$
R_2	$C + CO_2 = 2CO$
R_3	$FeO + C = Fe + CO$
R_4	$FeO_x + H_2 = FeO_{x-1} + H_2O$
R_5	$C + H_2O = CO + H_2$
R_6	$CO + H_2O = CO_2 + H_2$
R_7	$C(coke) = [C]$
R_8	$SiO_2 + 2C = [Si] + 2CO$
R_9	$H_2O(liq) = H_2O(g)$
R_{10}	$CaCO_3 = CaO + CO_2$
R_{11}	$C + 1/2O_2 = CO$ (Raceway)
R_{12}	$C + H_2O = CO + H_2$ (Raceway)

Control of hot metal temperature (HMT) is important to realize an efficient and stable operation.

2D transient model of BF

- Finite volume method with adaptive cells
  32 cells in height direction X 3 cells in radial direction
- Optimal balance between ACCURACY and SPEED

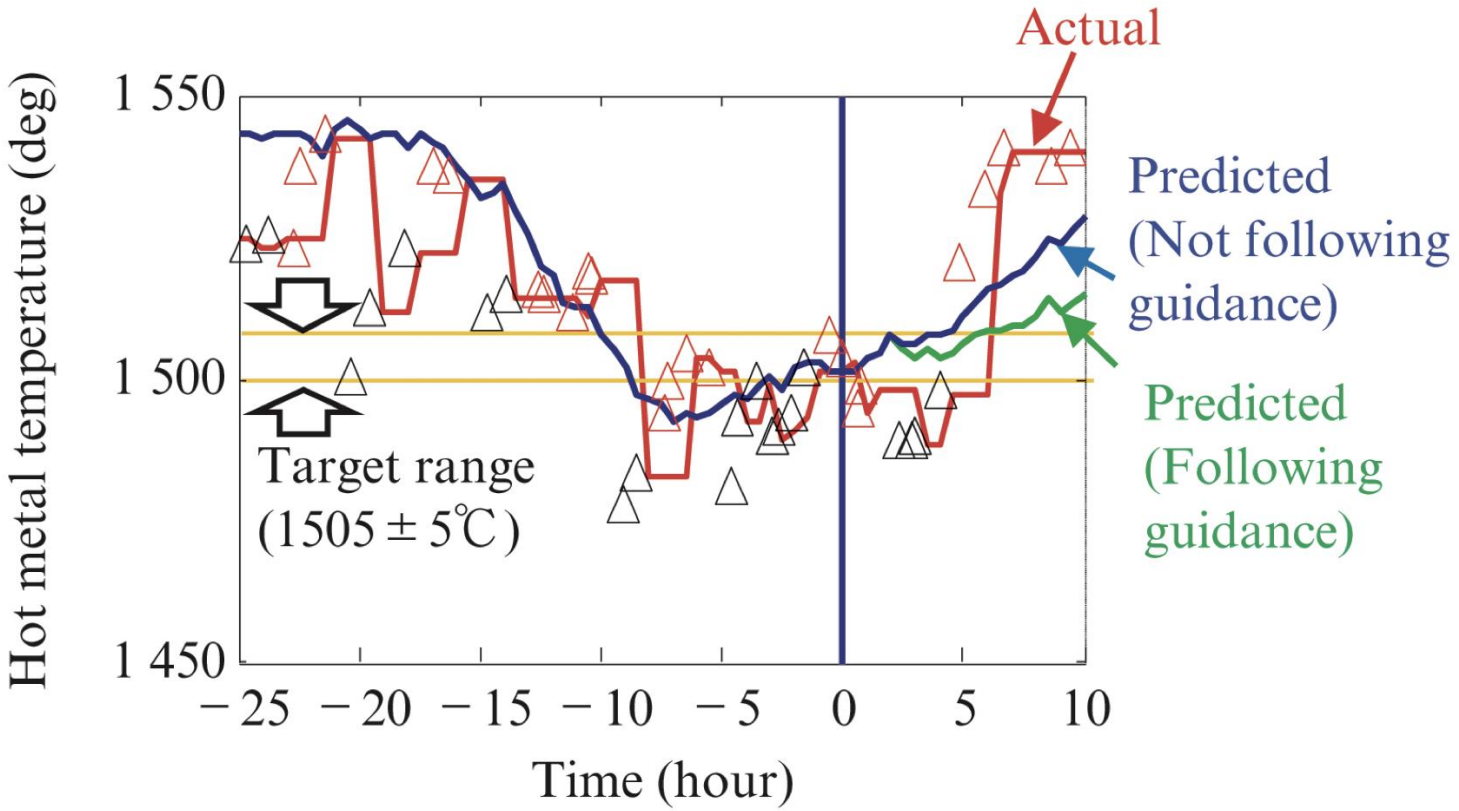


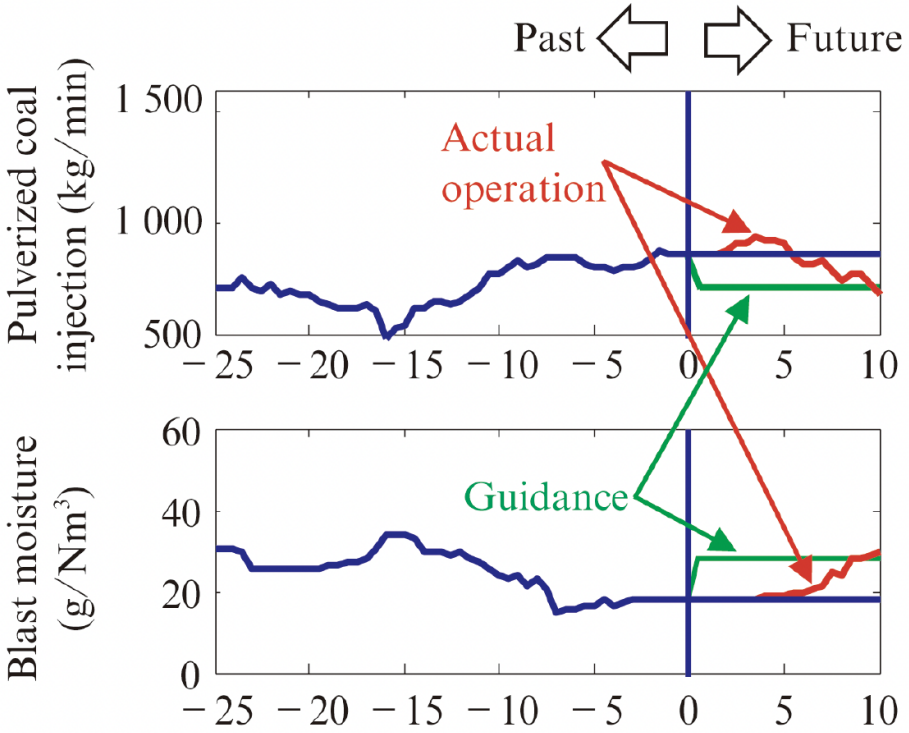


Calculated steady-state profiles

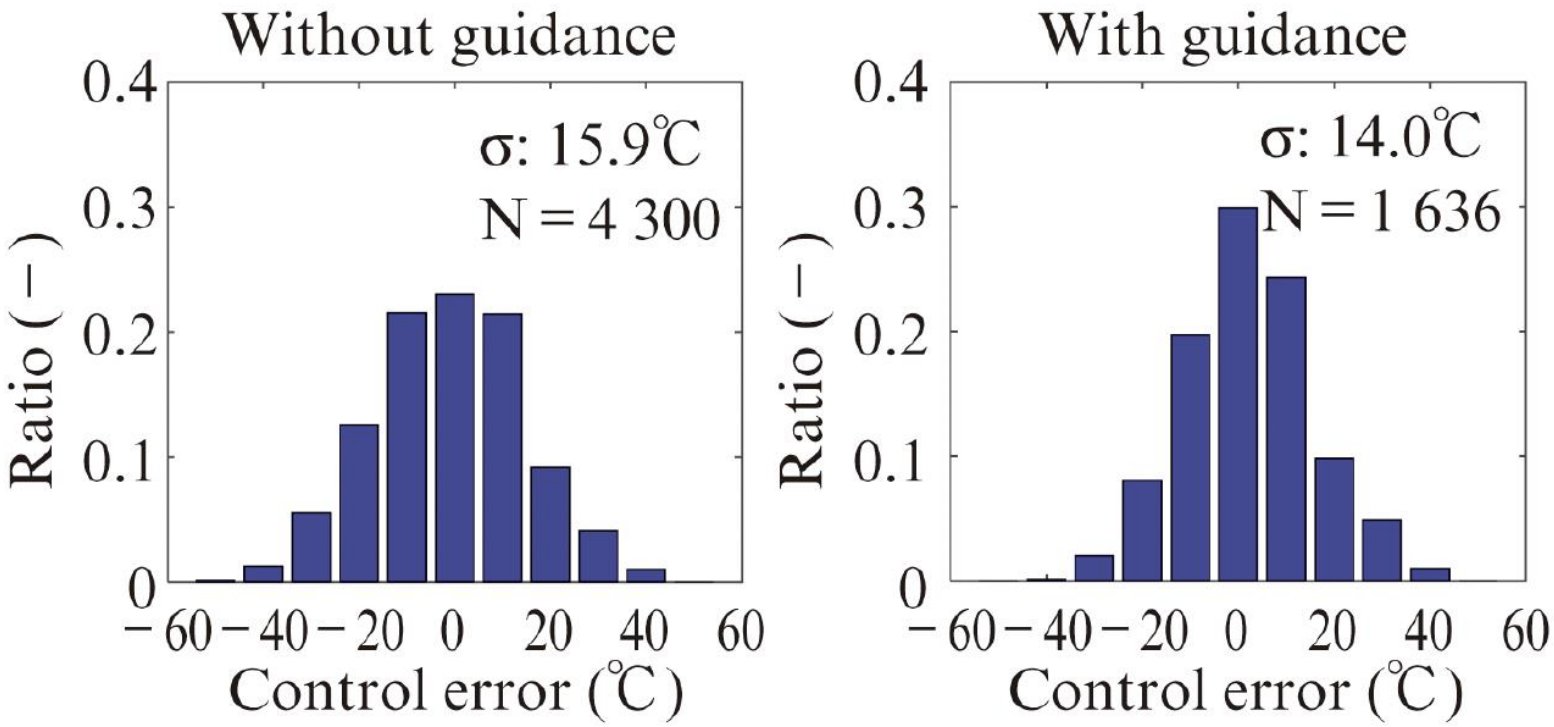
Operation guidance

- Nonlinear Dynamic Physical Model
- Moving Horizon Estimation (MHE)
- Nonlinear Model Predictive Control (NMPC)





Achievement by guidance system



We have achieved the significant reduction of CO2 emission and the production cost of iron.

AI applications in process industries

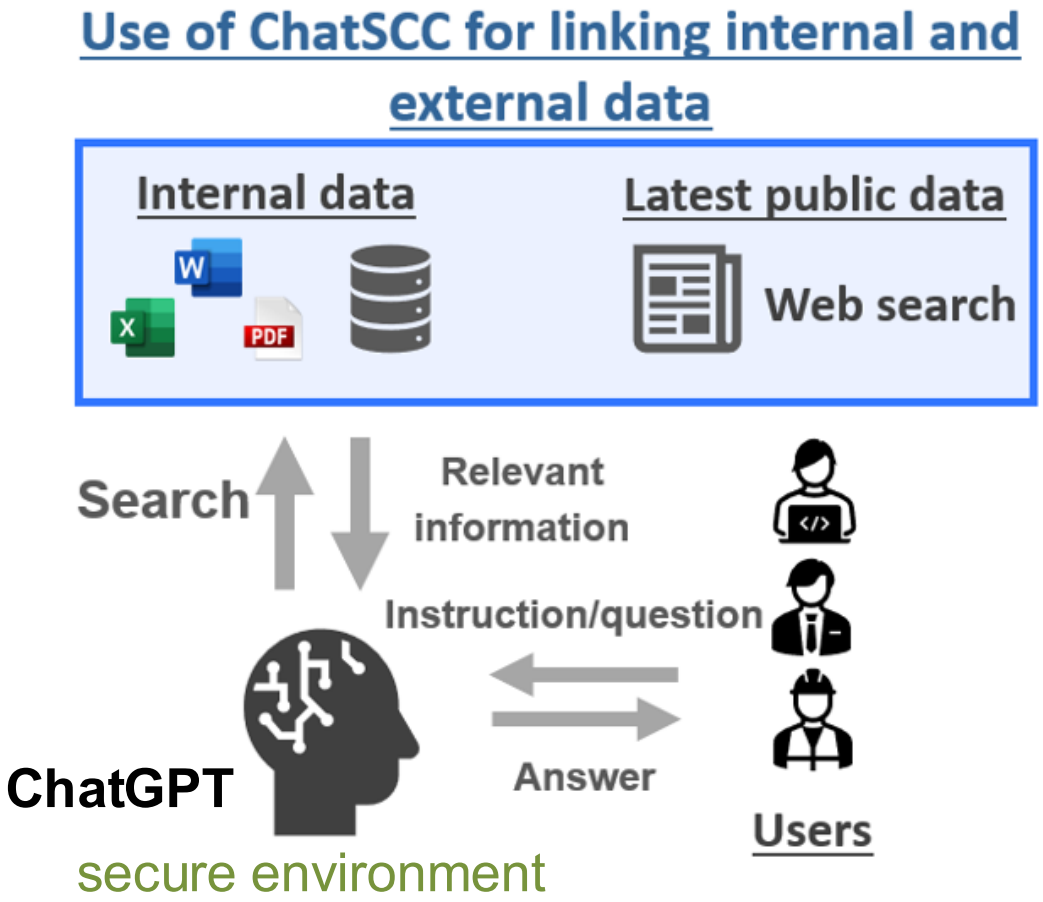
- Case 1
  - **In-house generative AI service "ChatSCC”**
  - improved operational efficiency by a maximum of over 50%.
- Case 2
  - **Automation of new application discovery**
  - increased the discovery of new applications with agility and accuracy.
- Case 3
  - **AI-based autonomous operation**
  - achieved higher stability and efficiency of crude distillation unit (CDU)
- Case 4
  - **AI-based operation support system**
  - achieved operational efficiency improvements of 40%

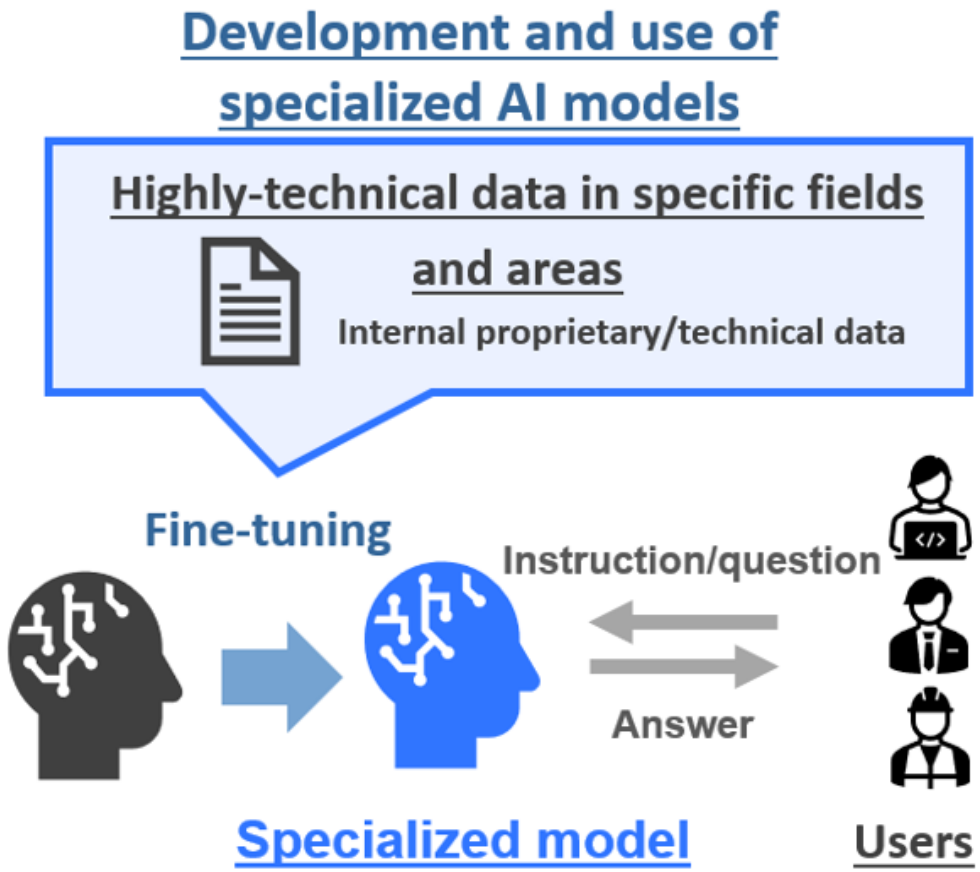
Case 1: In-house generative AI

- **In-house generative AI service "ChatSCC”**
  - Sumitomo Chemical
- Objective: dramatic improvement in productivity in the short term, enhancing the competitiveness, and creating new business models
- Key features:
  - Using ChatGPT
  - Available for all of its approximately 6,500 employees
  - Secure environment; input information will not leak outside
- Results: ChatSCC contributed to improving operational efficiency by a maximum of over 50%.

In-house generative AI service "ChatSCC"

Achieve a dramatic improvement in productivity in the short term with ChatSCC.





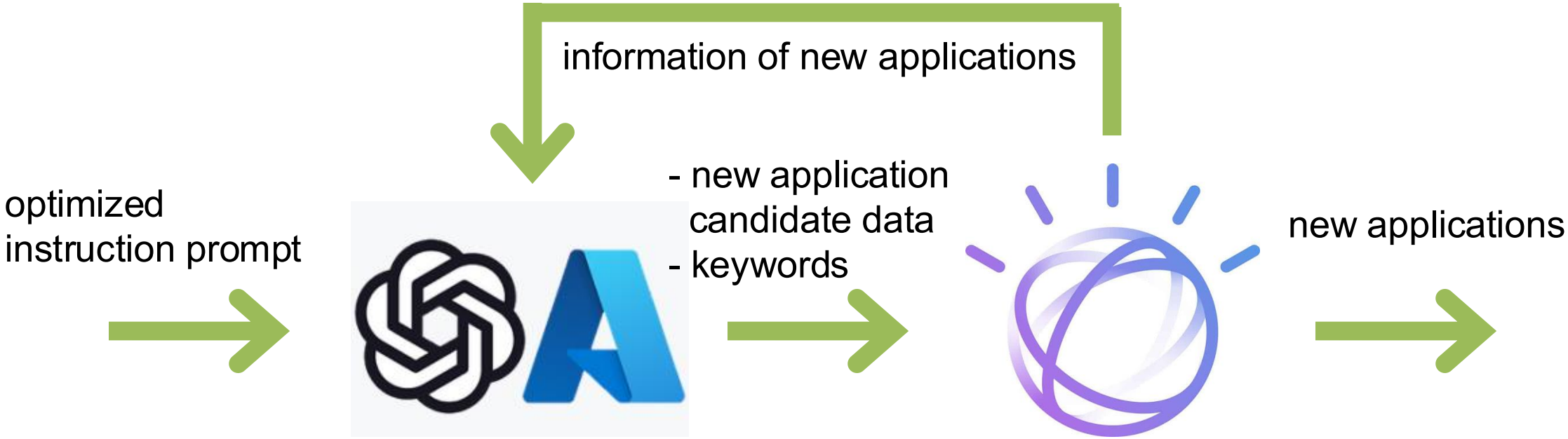
ChatSCC improved operational efficiency by a maximum of over 50% during the preliminary verification process

Case 2: New application discovery

- **Automation of new application discovery**
  - Mitsui Chemicals + IBM Japan
- Objective: expanding top line sales and market share by advancing DX.
- Key features:
  - Verifying higher agility and accuracy for new application discovery by combining Generative Pre-trained Transformer (GPT) with IBM Watson Discovery
- Results: GPT's generative and reasoning capabilities drastically increased the discovery of new applications with agility and accuracy.
  - Example: SNS analysis revealed many posts like "musty smell in the local railway," which led to sales activities of antifungal products to railway companies.

Automation of new application discovery

Accelerate new application discovery with high agility and accuracy by combining Generative AI (GPT) and IBM Watson.



GPT (Generative Pre-trained Transformer)

generates new candidates, and clarifies the reason and external environmental factors

external multimodal big data, such as patents, news, SNS, and videos

Case 3: Autonomous operation

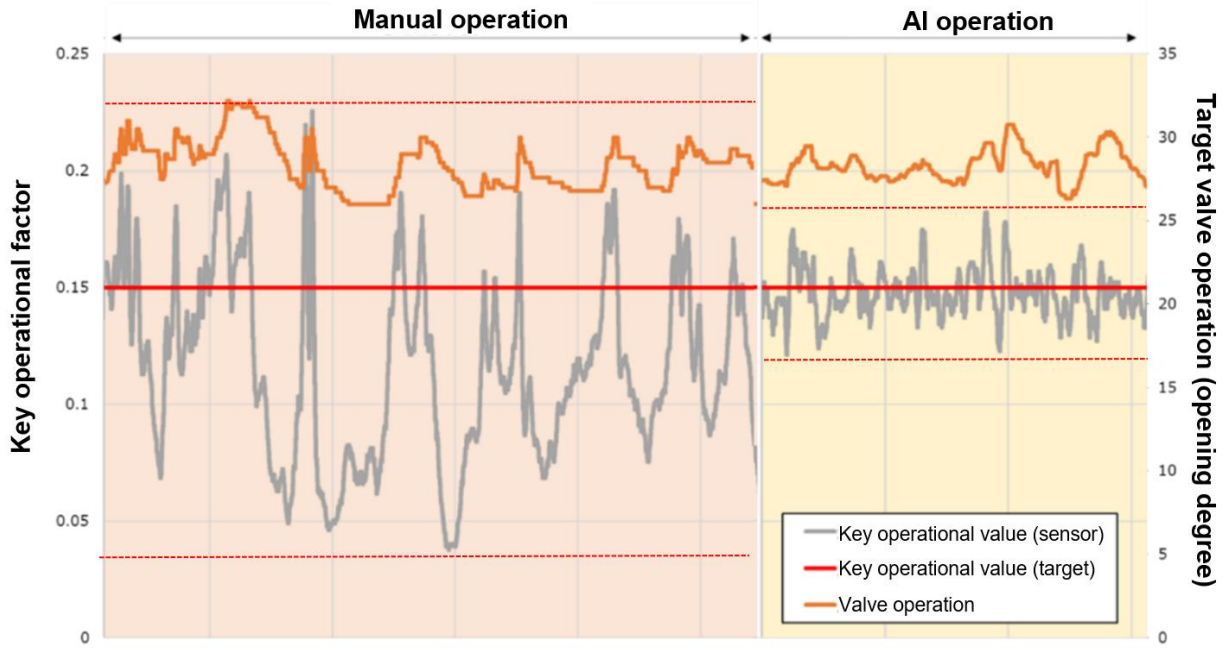
- **AI-based autonomous operation of crude distillation unit (CDU)**
  - ENEOS + Preferred Networks (PFN)
- Objective: improving stability of plant operations by reducing dependence on skilled operators.
- Key features:
  - Real application to CDU at the ENEOS Kawasaki Refinery
  - The world's first AI-based, continuous autonomous operation of CDU
  - Monitoring 24 key operational factors and adjusting 13 valves
- Results: The AI system demonstrated higher stability and efficiency compared with manual operations.
- ENEOS and PFN plan to deploy the AI systems to other refineries and later provide them as a packaged solution to external parties as well.

AI-Based autonomous operation of crude distillation unit (CDU)

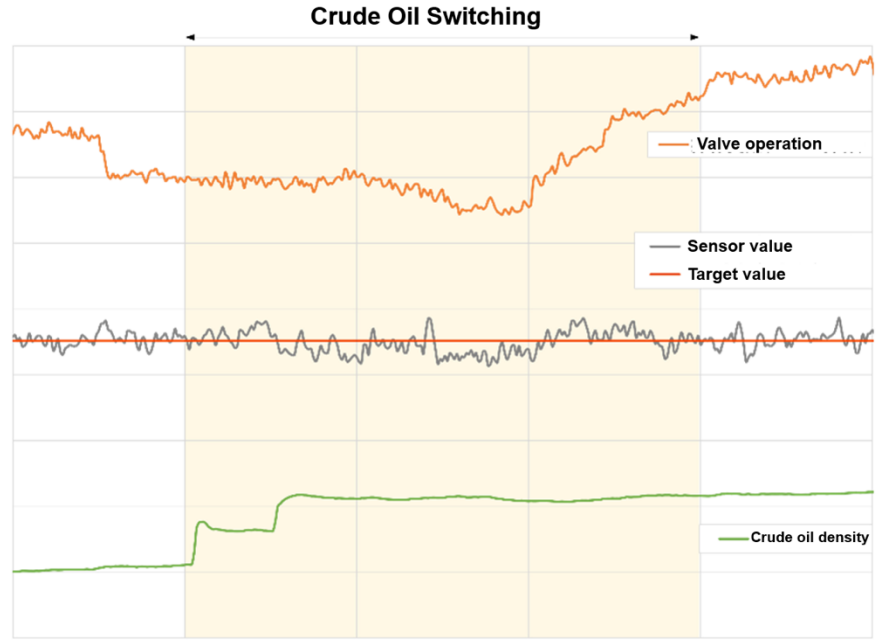
Improve stability of plant operations by reducing dependence on skilled operators.

The AI system monitors 24 key operational factors and adjusts 13 valves to stabilize the CDU.

human operator AI



AI reduced the variability and improved the stability against disturbances



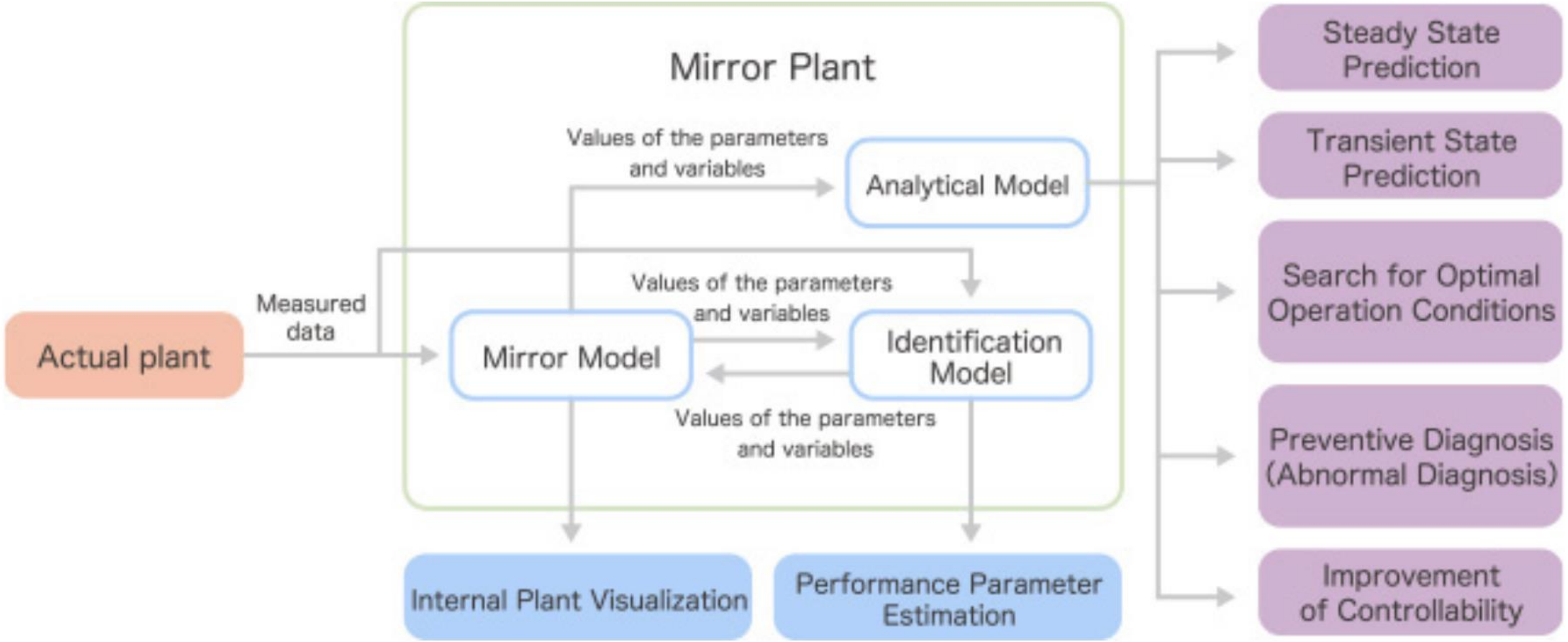
AI achieved the stability even during crude oil switching operations

Case 4: Operation support

- **AI-based operation support system**
  - NEC, National Institute of Advanced Industrial Science and Technology (AIST), Mitsui Chemicals, and Omega Simulation
- Objective: developing an operation support system to improve operational efficiency
- Key features:
  - Combining Logical Thinking AI with Mirror Plant
  - Logical Thinking AI, employing reinforcement learning, explains the rationale behind operational decisions.
- Results: The system achieved operational efficiency improvements of 40% compared to manual operation by operators.

Mirror Plant @Omega Simulation

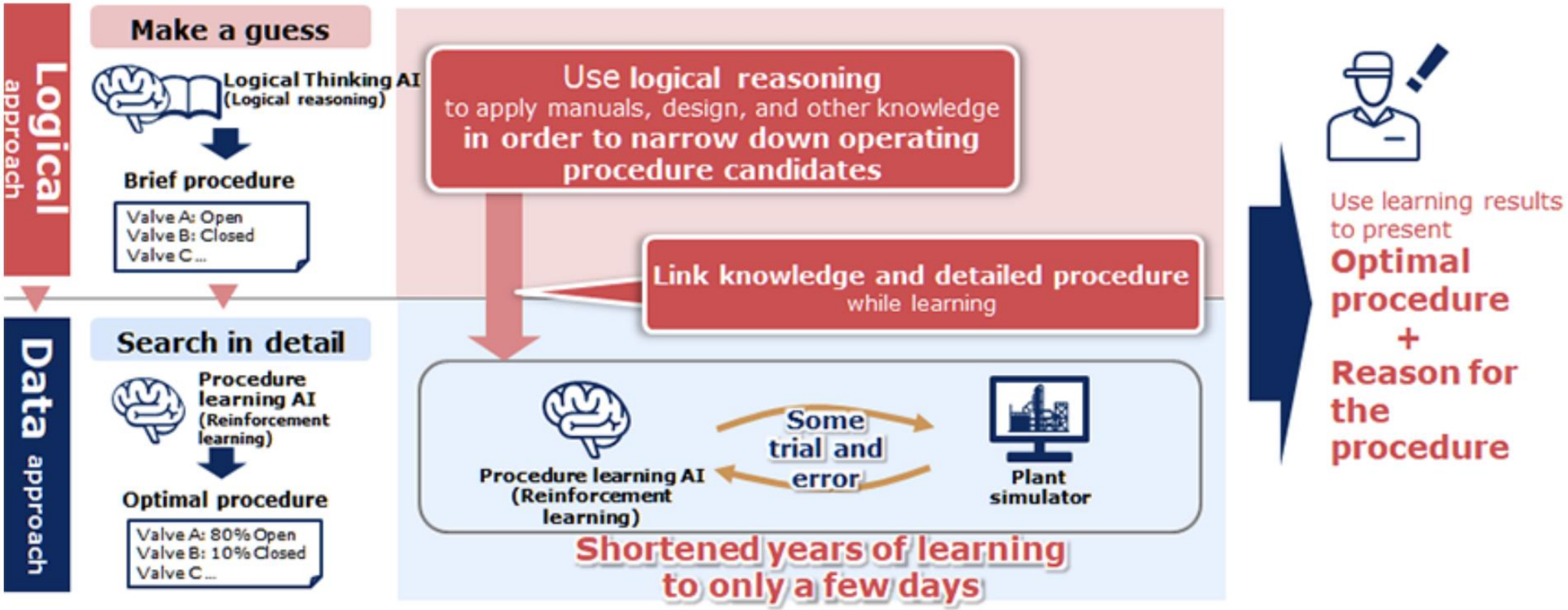
- Online, rigorous, dynamic plant simulator



Omega Simulation Co., LTD.

Logical Thinking AI @NEC

- Reasoning model that interprets the result logically with reasons



AI-based operation support system

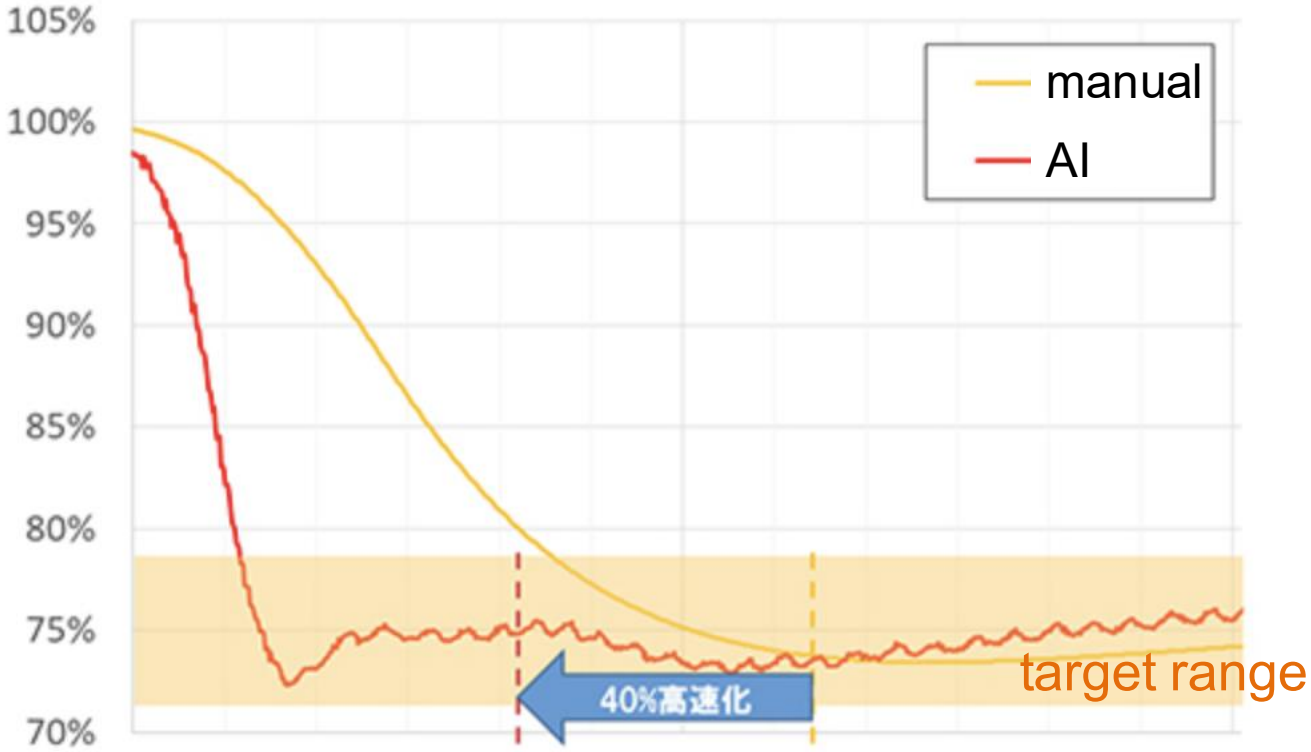
Mirror Plant

Logical Thinking AI
accelerates RL.

operators

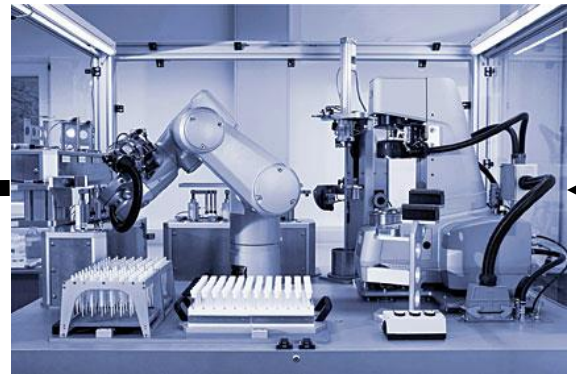
Logical Thinking AI

The AI system reduced operational time for changing production volumes by 40% compared to manual operation.



time reduction by 40%

Enhancing speed and efficiency of materials development



autonomous robot experiment

Comprehensive technical capabilities are required.
simulation,
Bayes optimization,
transfer learning,
reinforcement learning, etc.

multimodal experiment data

papers, patents, docs

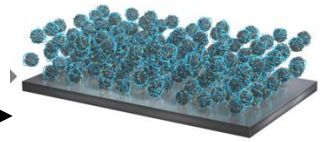
materials development AI

Design space exploration

$$X = f^{-1}(Y)$$

Materials performance prediction

$$Y = f(X)$$



new materials

Automated physical model builder (AutoPMoB)

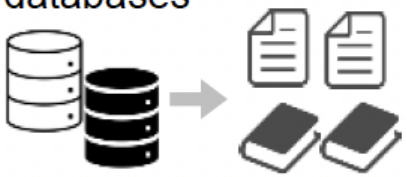
AI for automatically constructing physical models from scientific literature

Retrieve documents	Extract information and unify expression	Build and rank model candidates

- Expert knowledge and skills
- Time-consuming trial-and-error

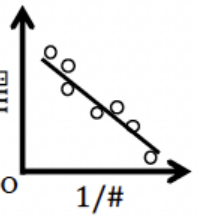
Conventional method: Manual procedure

Retrieve documents related to the target process from literature databases



Extract information required for physical model building and unify its expression.

Symbol	Definition
!	volume
"	temperature
⋮	⋮



Build, validate, and rank model candidates.

- Model candidate1
- Model candidate 2
- Model candidate 3

AutoPMoB: Automation by AI

Physical model

$$\frac{d"}{d\#} = \%_{0} - \%$$

$$\vdots$$

$$' = '_{!}\exp(-\frac{'}{-\cdot})$$

$$-0_{\cdot} = ' 1_{"}$$

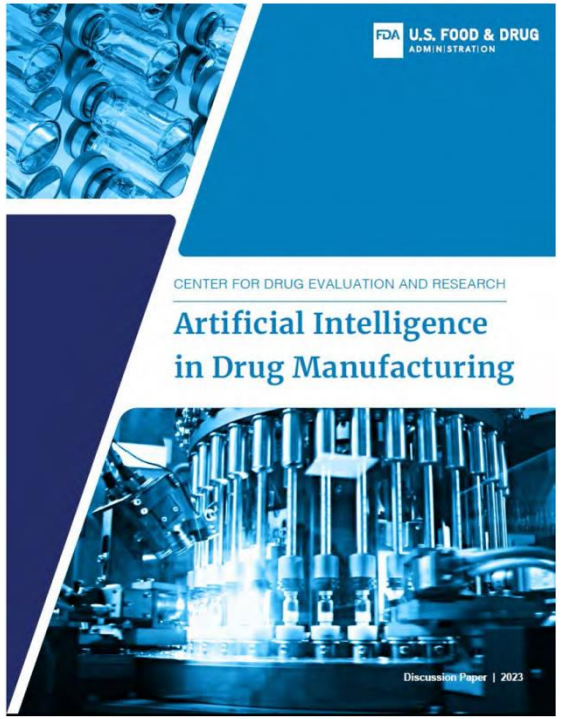
$$\frac{d1_{"}}{d\#} = \frac{\%}{"}(1_{"!} - 1_{"}) + 0_{\cdot}$$

Symbol	Definition
!	volume
"	temperature
⋮	⋮

Digital Twins

Initiatives for innovative pharmaceutical manufacturing

- US FDA
  - Emerging Technology Team (ETT)
  - Adopting novel manufacturing approaches involves both technical and regulatory challenges. To address regulatory concerns at an early stage, the FDA launched the Emerging Technology Program (ETP).
- EMA
  - Quality Innovation Group (QIG)
  - Supporting the transition to innovative approaches in drug development, manufacturing, and quality control.




EUROPEAN MEDICINES AGENCY
SCIENCE MEDICINES HEALTH

13 July 2023
EMA/CHMP/CVMP/83833/2023
Committee for Medicinal Products for Human Use (CHMP)
Committee for Medicinal Products for Veterinary Use (CVMP)

Reflection paper on the use of Artificial Intelligence (AI) in the medicinal product lifecycle

Draft

Draft agreed by Committee for Medicinal Products for Human Use (CHMP) Methodology Working Party	July 2023
Draft adopted by CVMP for release for consultation	13 July 2023
Draft adopted by CHMP for release for consultation	10 July 2023
Start of public consultation	19 July 2023
End of consultation (*deadline for comments*)	31 December 2023

Comments should be provided using this EUSurvey form. For any technical issues, please contact the EUSurvey Support.

Keywords	*Artificial intelligence, AI, machine learning, ML, regulatory, medicine, human medicinal product, veterinary medicinal product*

FDA Draft Guidance, January 2025

- This guidance provides recommendations to sponsors and other interested parties on the use of artificial intelligence (AI) to produce information or data intended to support regulatory decision-making regarding safety, effectiveness, or quality for drugs.
- Specifically, this guidance provides a risk-based credibility assessment framework that may be used for establishing and evaluating the credibility of an AI model for a particular context of use (COU).

Contains Nonbinding Recommendations

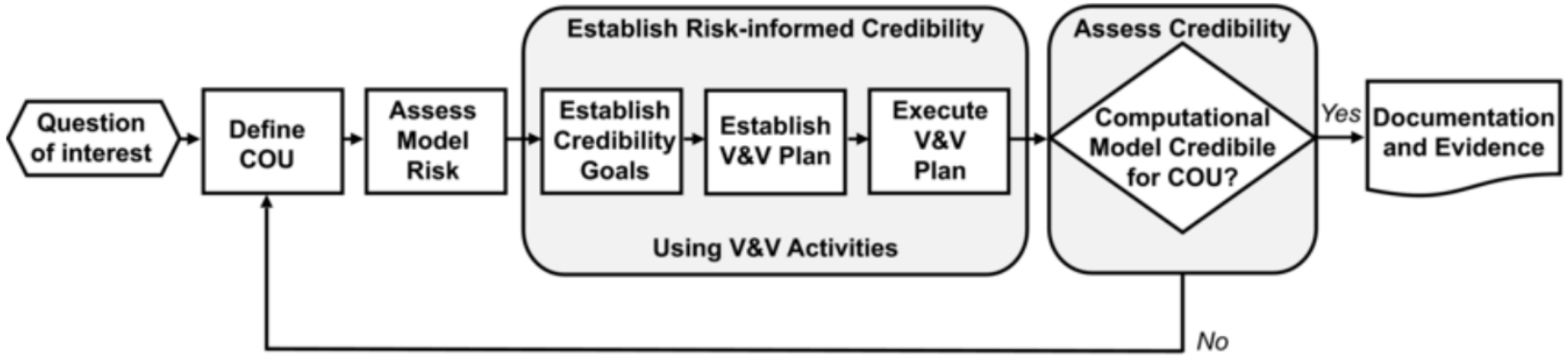
Draft — Not for Implementation

Considerations for the Use of Artificial Intelligence to Support Regulatory Decision-Making for Drug and Biological Products
Guidance for Industry[1] and Other Interested Parties

> This draft guidance, when finalized, will represent the current thinking of the Food and Drug Administration (FDA or Agency) on this topic. It does not establish any rights for any person and is not binding on FDA or the public. You can use an alternative approach if it satisfies the requirements of the applicable statutes and regulations. To discuss an alternative approach, contact the FDA staff responsible for this guidance as listed on the title page.

ASME Verification and Validation (V&V)

- The ASME Verification and Validation (V&V) standards provide a systematic framework to assess the accuracy and reliability of computational models, particularly those used in engineering simulations.
  - **Verification** ensures that the mathematical model is correctly implemented in the code (i.e., "solving the equations right").
  - **Validation** checks whether the model accurately represents the real-world system (i.e., "solving the right equations").
- These standards are widely applied in fields such as mechanical, aerospace, and biomedical engineering to ensure confidence in simulation results used for design, safety, and regulatory decisions.



Summary

AI / ML-Enabled Digital Transformation of Japan's Process Industries

- Key messages
  - Domain knowledge is crucial for data utilization and effective AI deployment.
  - Generative AI and LLMs as well as ML are available for industrial use.
  - Digital twins and cyber-physical systems are becoming reality.
- Recent work: limited examples
  - Digital twin and cyber-physical system (CPS) for blast furnace
  - In-house generative AI service
  - New application discovery
  - AI-Based autonomous operation and operation support system
  - New materials development
  - Automated physical model builder
- Evaluation of the credibility of AI models.