



**Boost your glass-quality  
with simulation-assisted AI**

**The  
concept**

CFD-  
powered  
AI

How  
does it  
look like

What's  
next

# FURNACE CONTROL SYSTEMS



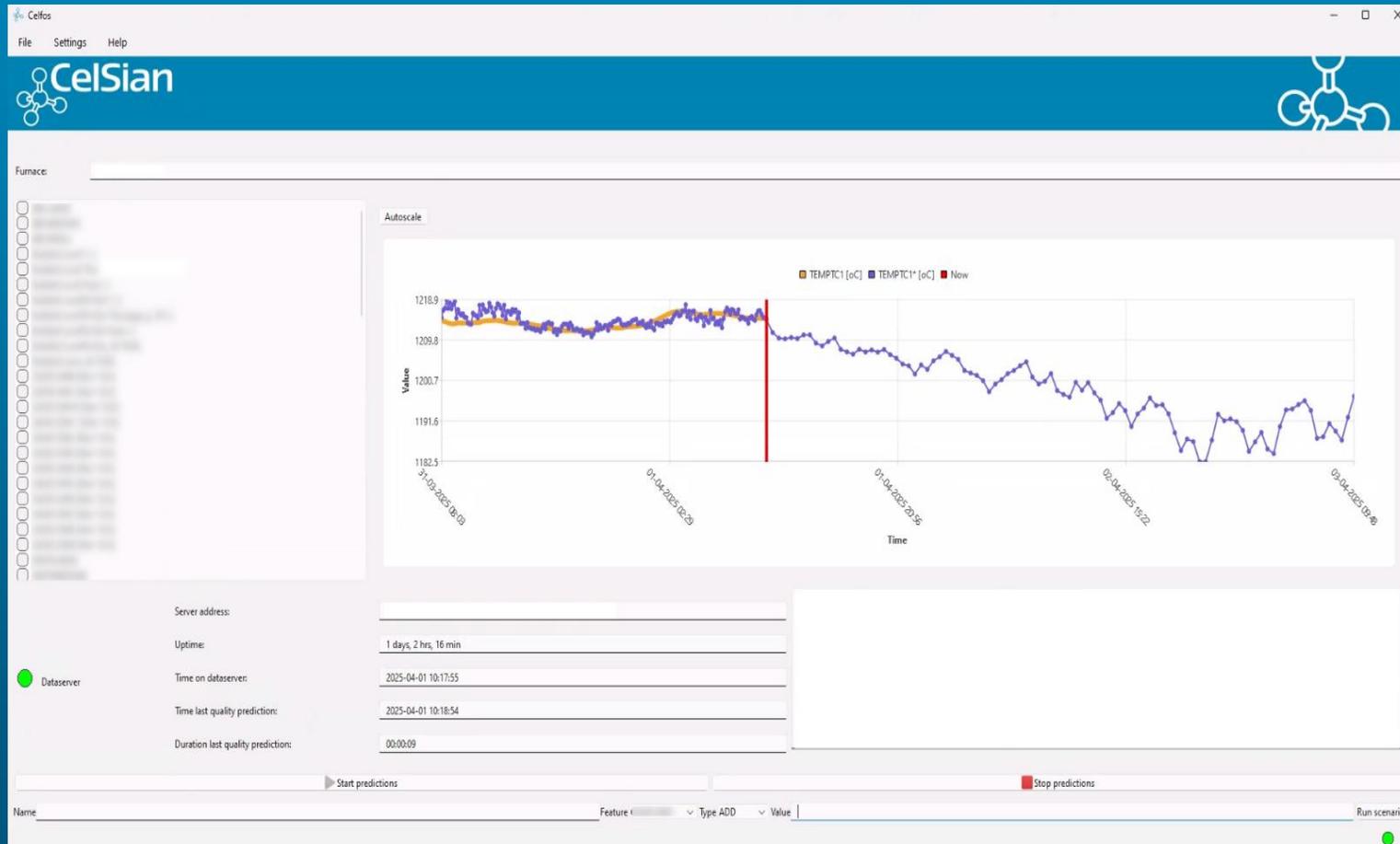
**Traditional goal: stable temperature**

# FURNACE CONTROL SYSTEMS



**The real goal**

# Celfos



# QUALITY CONTROL

Glass already seen most of it's time-temperature trajectory. Not much you can do.

Accurate prediction of future (24-48 hours) quality available. Reaction/action possible.



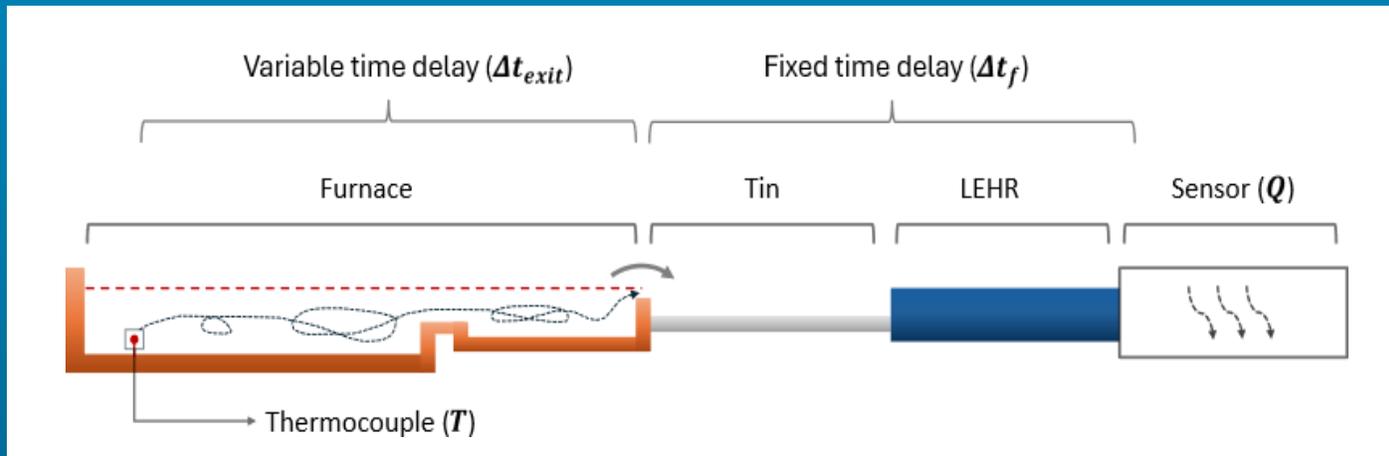
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## GLASS QUALITY AI MODEL: CHALLENGES



1. **Dominant parameters** affecting quality are **unknown**
2. **Time delays** are **unknown**
3. **Clean responses** can't be obtained from **furnace data alone**

# OUR SOLUTIONS

**!** Dominant parameters affecting quality are **unknown**

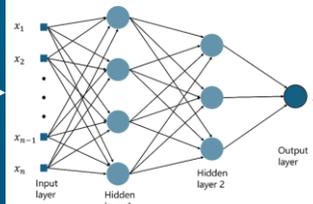
**✓** Complex Neural Networks

**✓** Use GPU

### Furnace parameters:

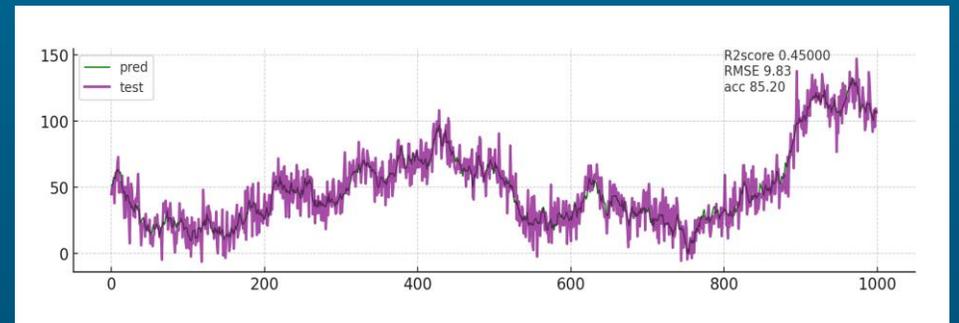
- Temperature
- Pull
- Flow dynamics
- Boosting, etc.

### AI



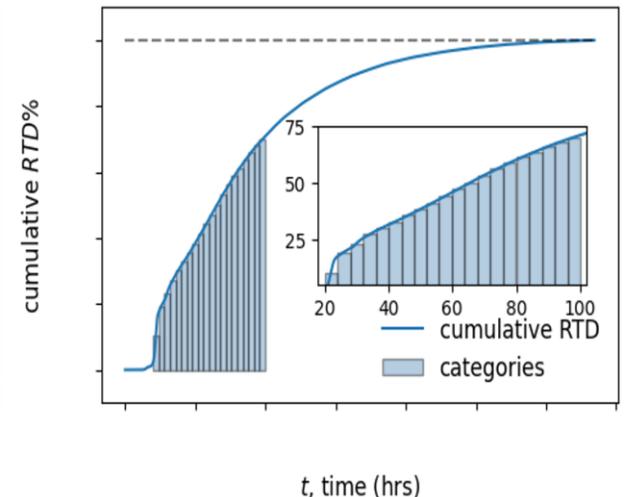
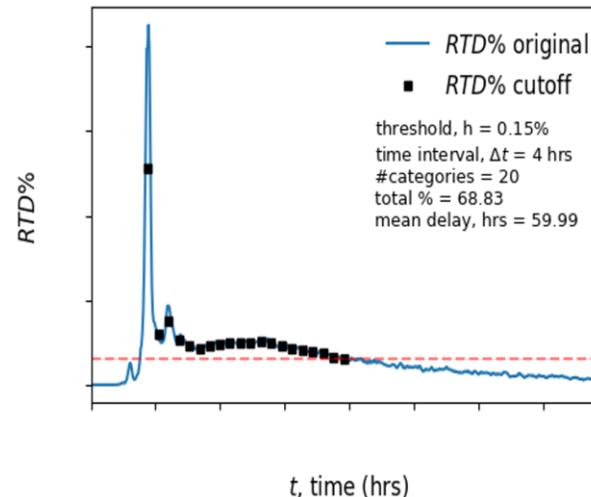
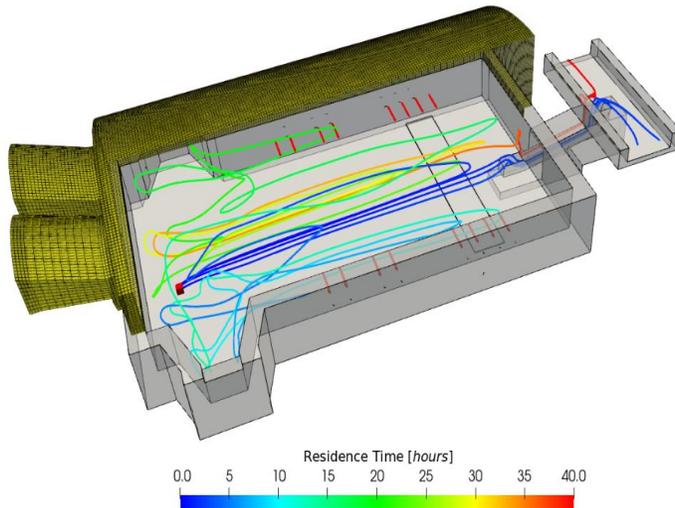
### Defects:

- Bubbles
- Knots
- Stones, etc.



# OUR SOLUTIONS

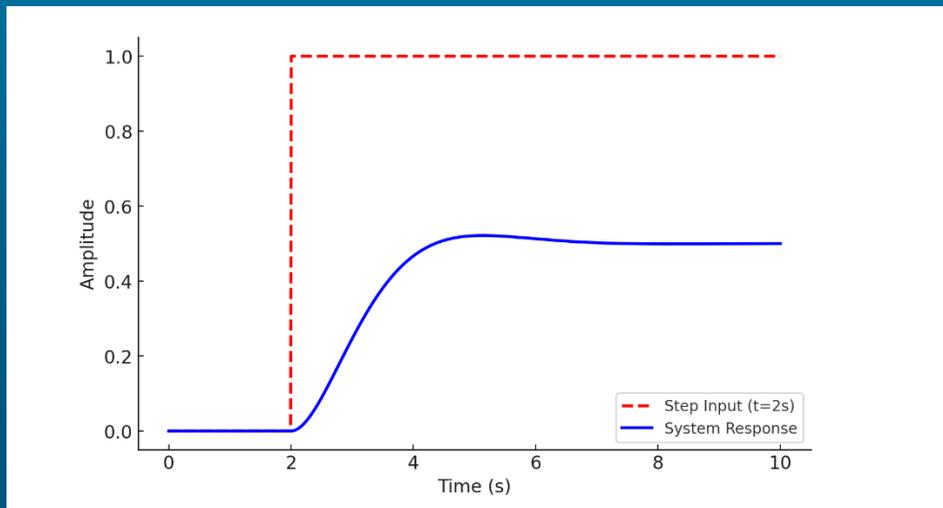
- ❗ Time delays are unknown
- ✅ Couple the AI model with a CFD model (GTM-X)



## OUR SOLUTIONS

❗ Clean responses can't be obtained from furnace data alone

✅ Couple the AI model with a time-transient CFD model



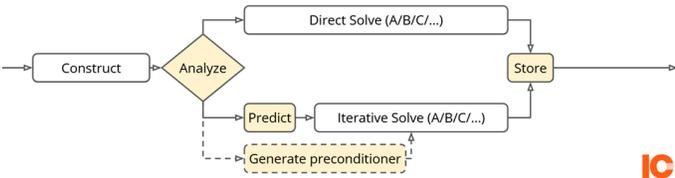
# OUR SOLUTIONS

- ❗ Time-transient CFD simulations are very computationally expensive
- ✅ Speed-up GTM-X CFD simulation using GPU and AI-enhanced solvers

**Simulation cycle**

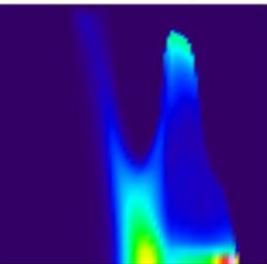


**Our approach**



**PLASIMO example (6.6x faster)**

2D drift-diffusion model of discharge with complex mixture



CPU time [s]

Solver	CPU time [s]
Direct solver	693.57
Direct-GMRES	117.23
Direct-BICGSTAB	102.19

10960 cases, rtol=1e-7



Rijksdienst voor Ondernemend Nederland

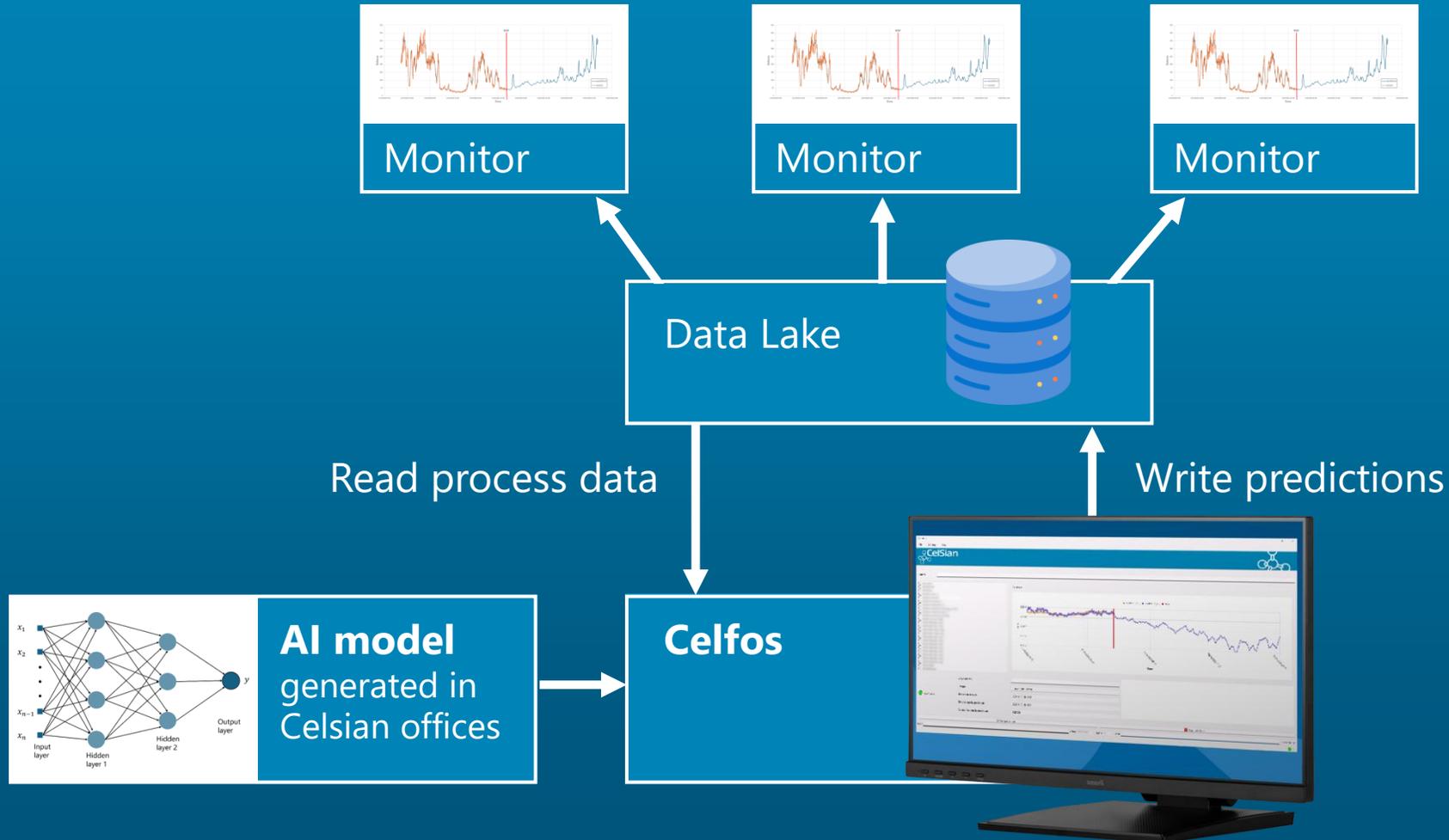
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# SOFTWARE STRUCTURE



## WHAT THE USER SEES

A screen matching the user's wishes/look and feel, showing the predicted quality and temperatures

Recognize upcoming problems and information on the past performance of the model (build confidence)



## ADDITIONAL BENEFITS

- **Deep insight into the dominant parameters**
- **Incorporation of the production schedule**

## CURRENT STATUS

- **Successfully applied** on a float furnace
- **Running** since Q4 2024
- **Accuracy >90%**

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# CELFOS ROADMAP

Container and a Fibre glass project started

Q2 2025

Functionality to **detect mal-functioning of sensors** will be added

Q3 2025

Once the quality predictor runs smoothly, a **recommender** can be added advising operators on what to do. The recommender is currently under development and will be tested in 2025.

Q3 2025

The recommender advises the operator for **changing set-points to obtain good-quality glass at the lowest cost** (including complex process settings changes over time)

*“The current quality is good, however in about 30 hours an increase in medium-sized bubbles is expected. Therefore it is recommended to increase the total gas flow to 1356 Nm<sup>3</sup>/h in 7 hours from now. To minimize the energy usage, in 16 hours from now the total gas flow can be lowered to 1285 Nm<sup>3</sup>/h”*



## On-site support

**Furnace process measurements**

**Energy audits**

**Advanced sensors**

- Combustion
- Refractory temperature
- Batch (R&D)



## Process optimization

**Advanced software solutions**

- Benchmark
- Operator support (EBM)
- Design optimization (GTM-X)
- Process control (Celfos)
- Microgrid solutions



## Academy

**To meet the challenges of furnace operation and glass production**

**35** years of experience

**+2000** participants



## R&D cooperation

- Pre-competitive multilateral R&D projects
- Alternative raw materials
- Refractory materials (H<sub>2</sub>)
- Sensors
- Laboratory experiments

# They trust us





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