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Vysus Group

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Empowering Control Room Operators with AI HAZOPs

Agenda

- A few incidents to reflect on
- Digitalization and Industry 4.0
- HAZOP Assistant
- From co-piloting PSM to co-piloting Operations
- Control Room Assistant
- Case study

Alarms are useless unless you know what to do about them

- Three Mile Island, PA, US (1979) – Partial Meltdown
  "*Cacophony of undifferentiated alarms*"
- Milford Haven, UK (1994) – Refinery Explosion
  "*Operators did not respond to the flare KO drum high level alarm*"
- Puertollano, Spain (2003) – Refinery Flash Fire
  "*Alarms triggered but were unattended by personnel*"
- Plaquemine, LA, US (2023) – EtO Release
  "*Alarms triggered but 3 hours later, operators were unable to reduce the level in the reflux drum*"

It takes two to tango

- ANSI/ISA ISA18.2 Management of Alarm Systems for the Process Industries

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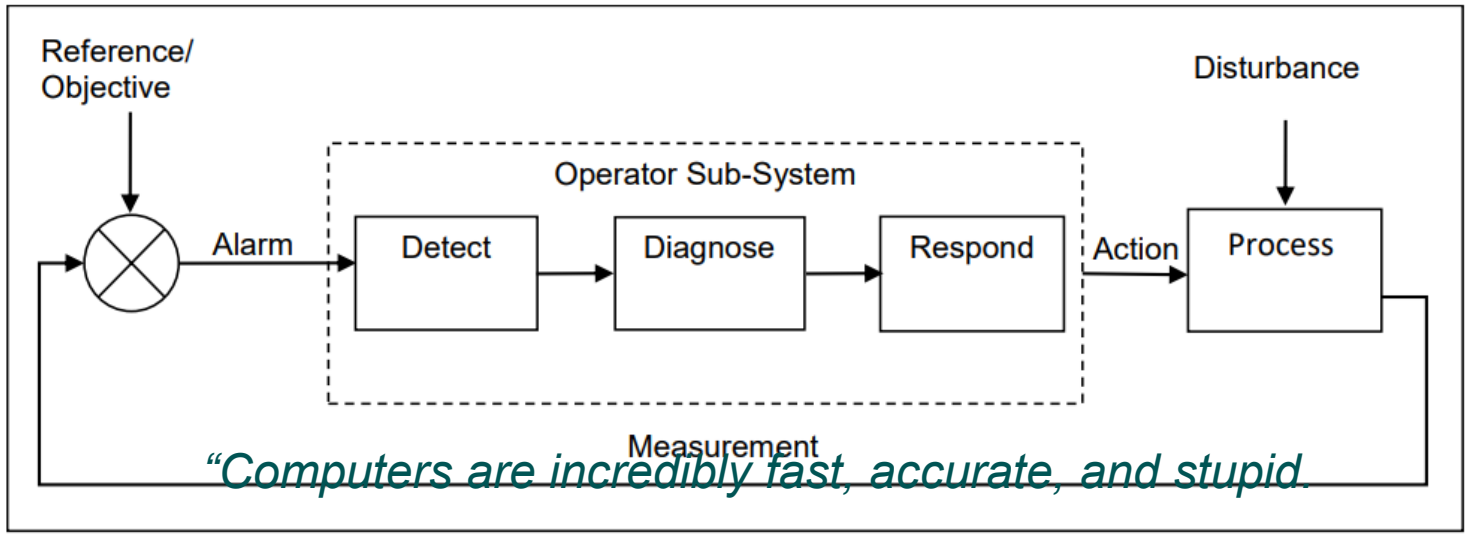
~6 alarms per
~1 alarm per 1



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"Computers are incredibly fast, accurate, and stupid.

Human beings are incredibly slow, inaccurate and brilliant.

Together they are powerful beyond imagination"

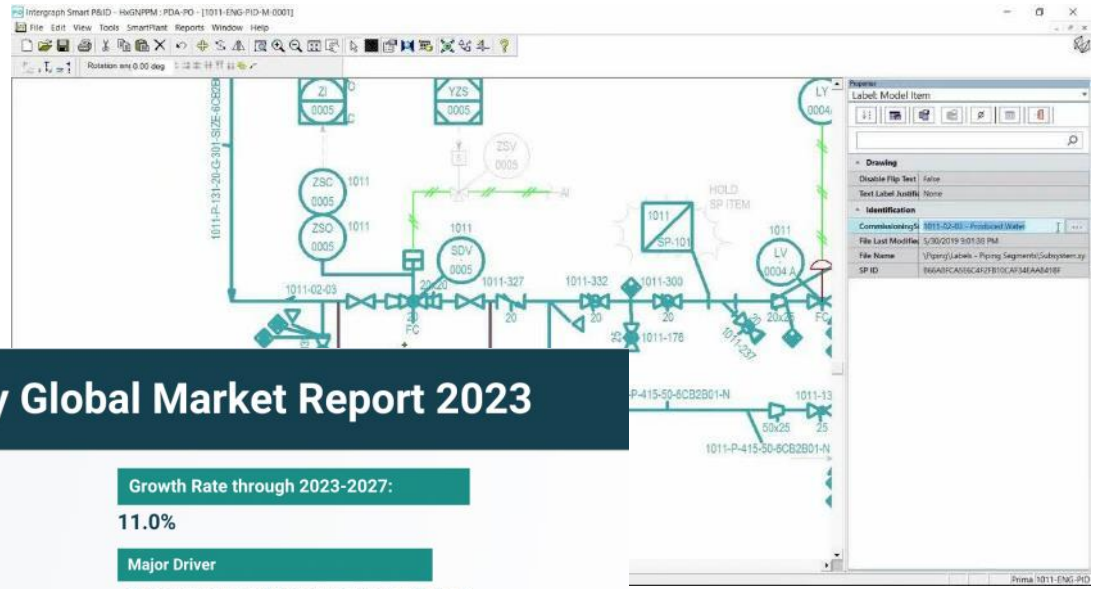
– Albert Einstein

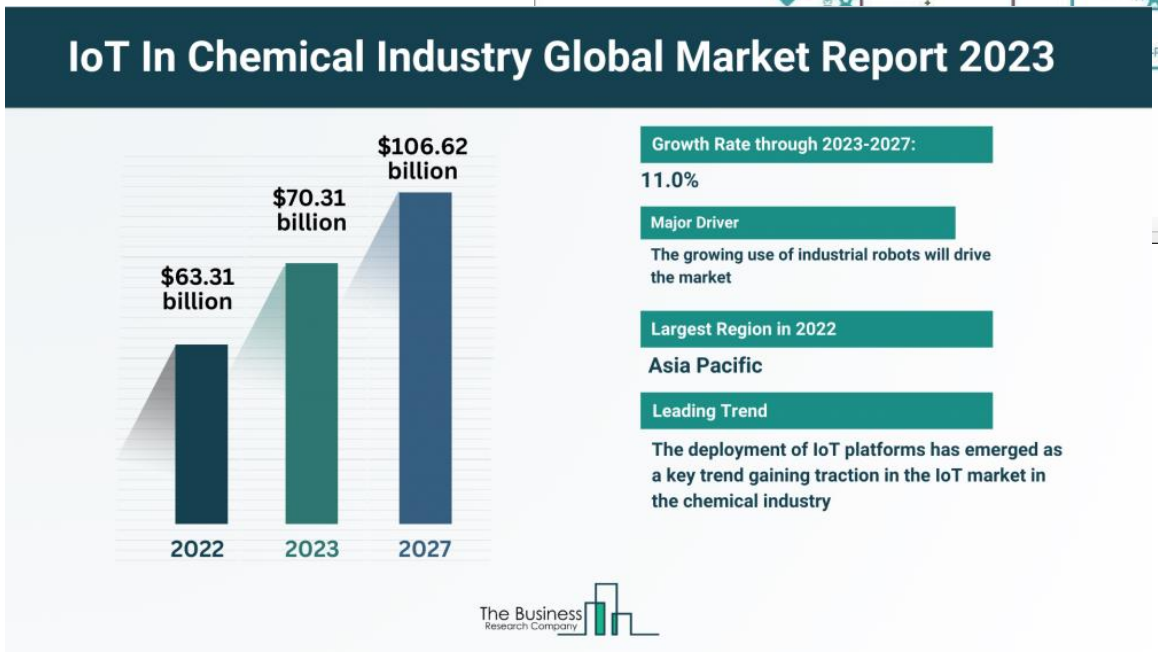
World is progressing into the digitalization

- Cell Phones
- E-Commerce
- Cloud Platforms
- Big Data
- Internet of Things

Is the PSM Community digitalizing?

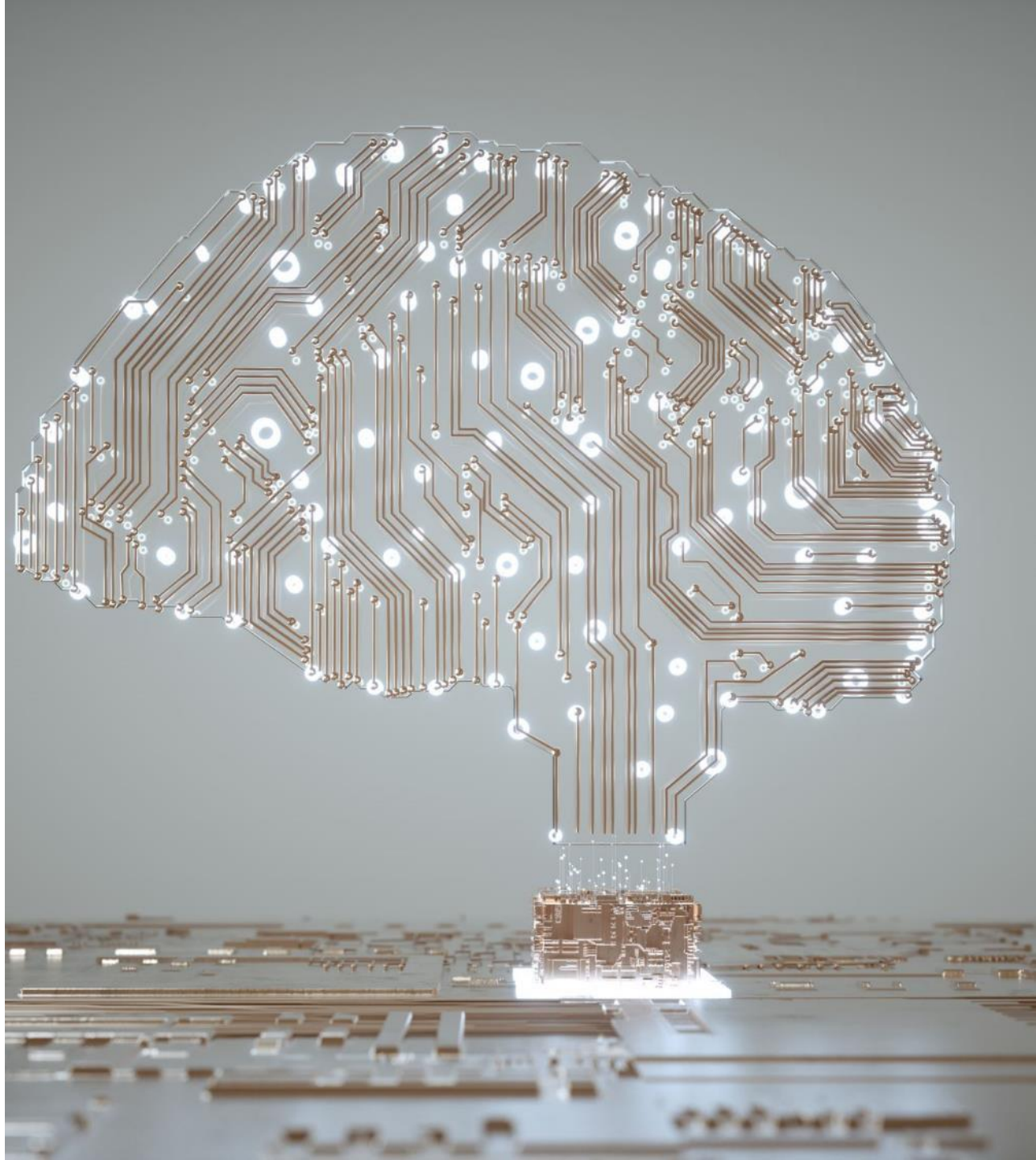
- Smart P&IDs
- Advanced Robotics
- 3D Printing
- Internet of Things
- Artificial Intelligence
- Big Data





Artificial Intelligence

- Narrow AI
  - **Reactive Machine AI**
  - **Limited Memory AI**
  - Theory of mind AI
  - Self Aware AI
- General AI
- Super AI



Who are we?

- Vysus Group
  - Multinational independent engineering and technical consultancy
  - Specialized in process safety and integrity

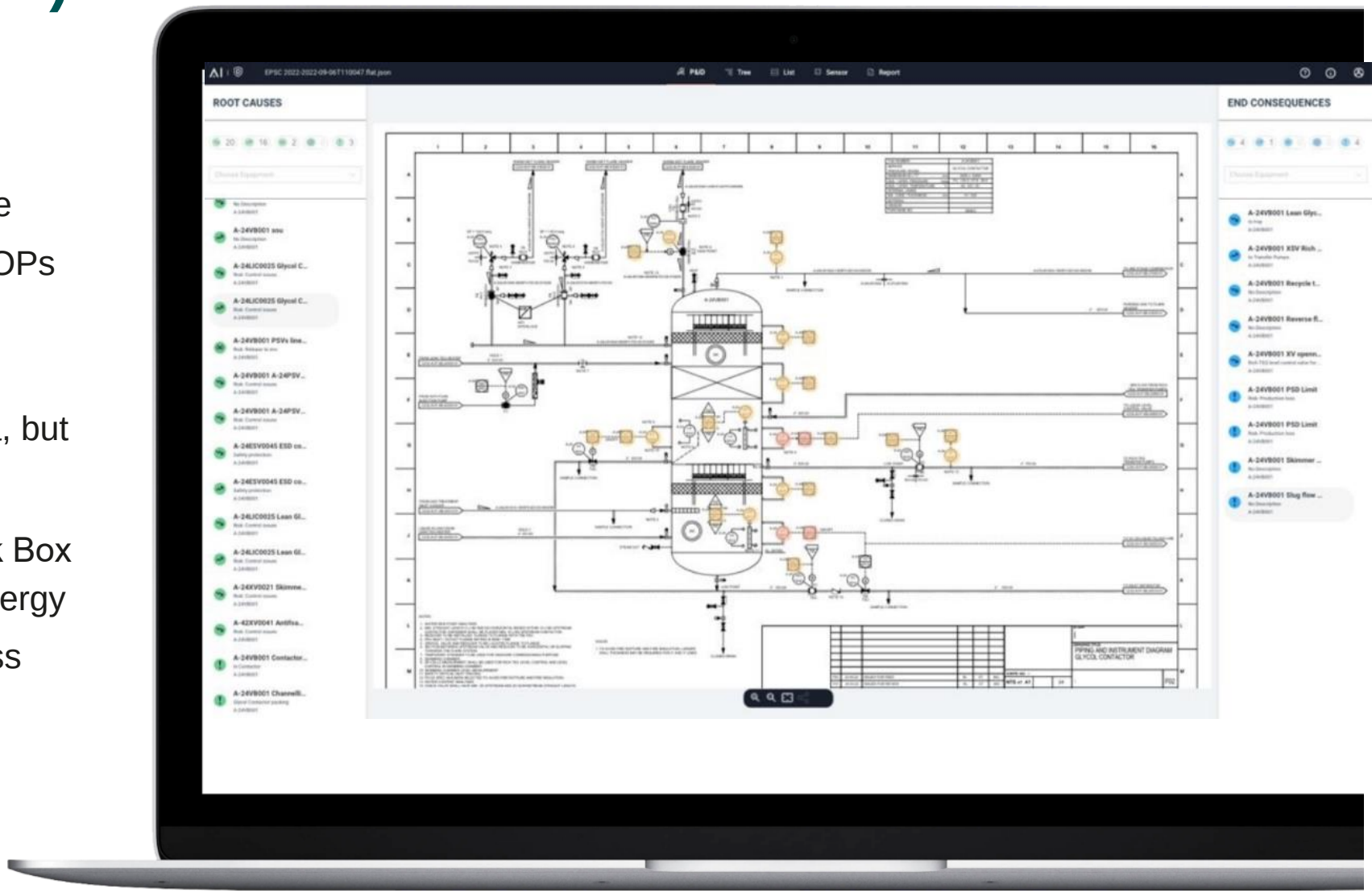
- Kairos Technology
  - Software development company
  - Specialized in plant automation

HAZOP Assistant (HA)

- Cloud-based software that uses functional modelling (MFM)
- MFM is an XAI modelling technique
- Uses a digital twin to support HAZOPs

- Uses qualitative physics (MFM)
  - AI is used to process the data, but data is developed by humans
  - Explainable AI (XAI) is deterministic, testable ≠ Black Box
  - Physical laws of mass and energy
- Not machine learning, not a process simulator

We don't want to substitute HAZOPs, but to improve them!



HAZOP Study – What happens afterwards?

- Actions are the main deliverable
  - “no actions, no improvement”
  - Actions are followed up and closed out
- HAZOP document
  - Unstructured, disorganized
  - Cannot be readily used to learn or disseminate knowledge
- Wait until next HAZOP
  - Knowledge is wasted in a shelf

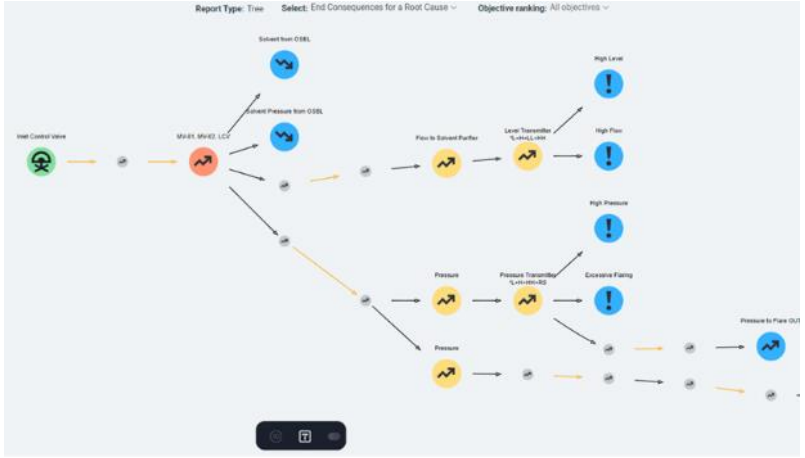
From co-piloting PSM to co-piloting Operations

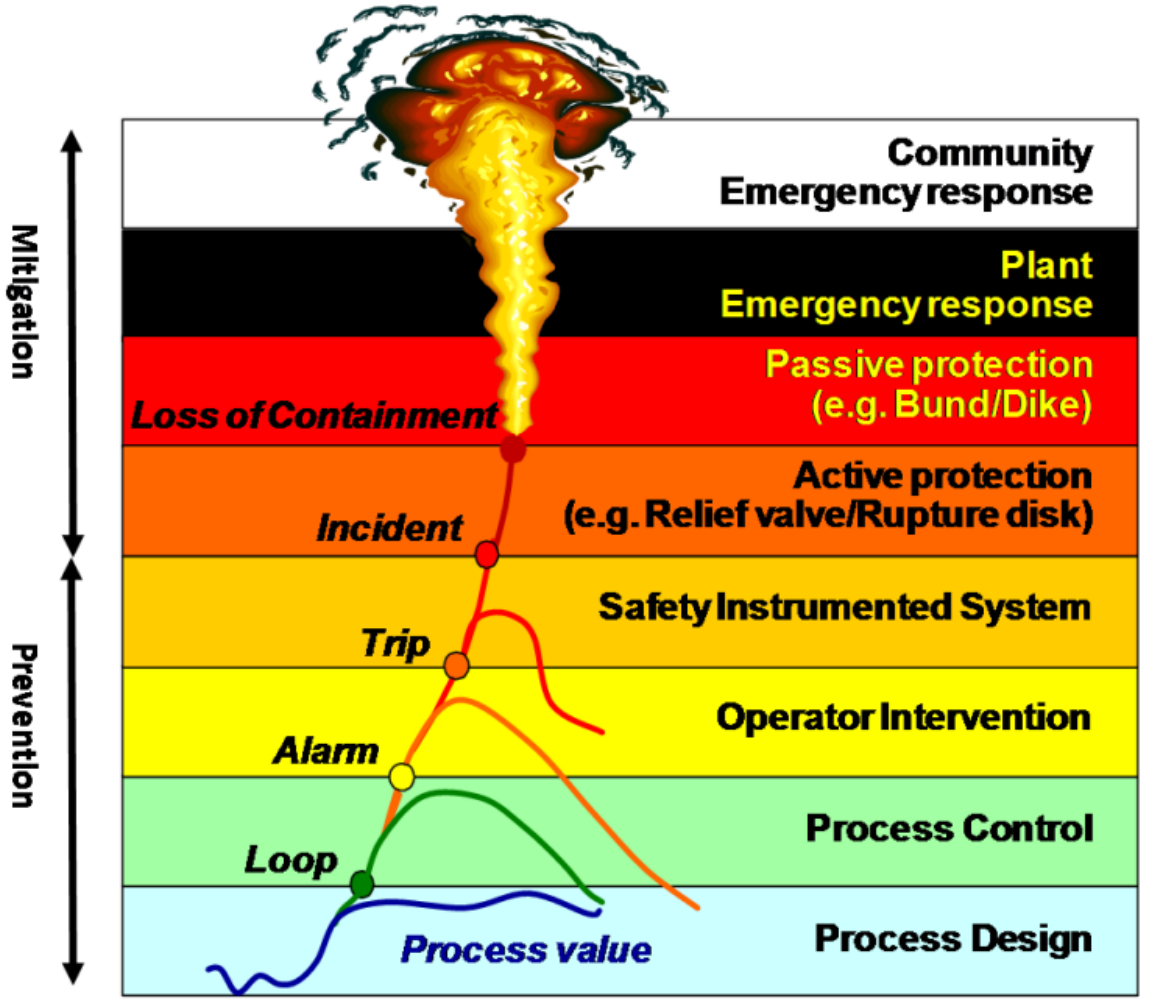
- We have developed a SW solution called Control Room Assistant (CRA)
- Decision support SW solution for control room operators
- Can learn as plant knowledge evolves
- Implemented in several projects

- Value
  - Avoids shutdowns
  - Reduces flaring due to production upsets
  - Production improvement
  - Reduces emissions
  - Additional savings in fuel gas and CO2 tax

Control Room Assistant (CRA)

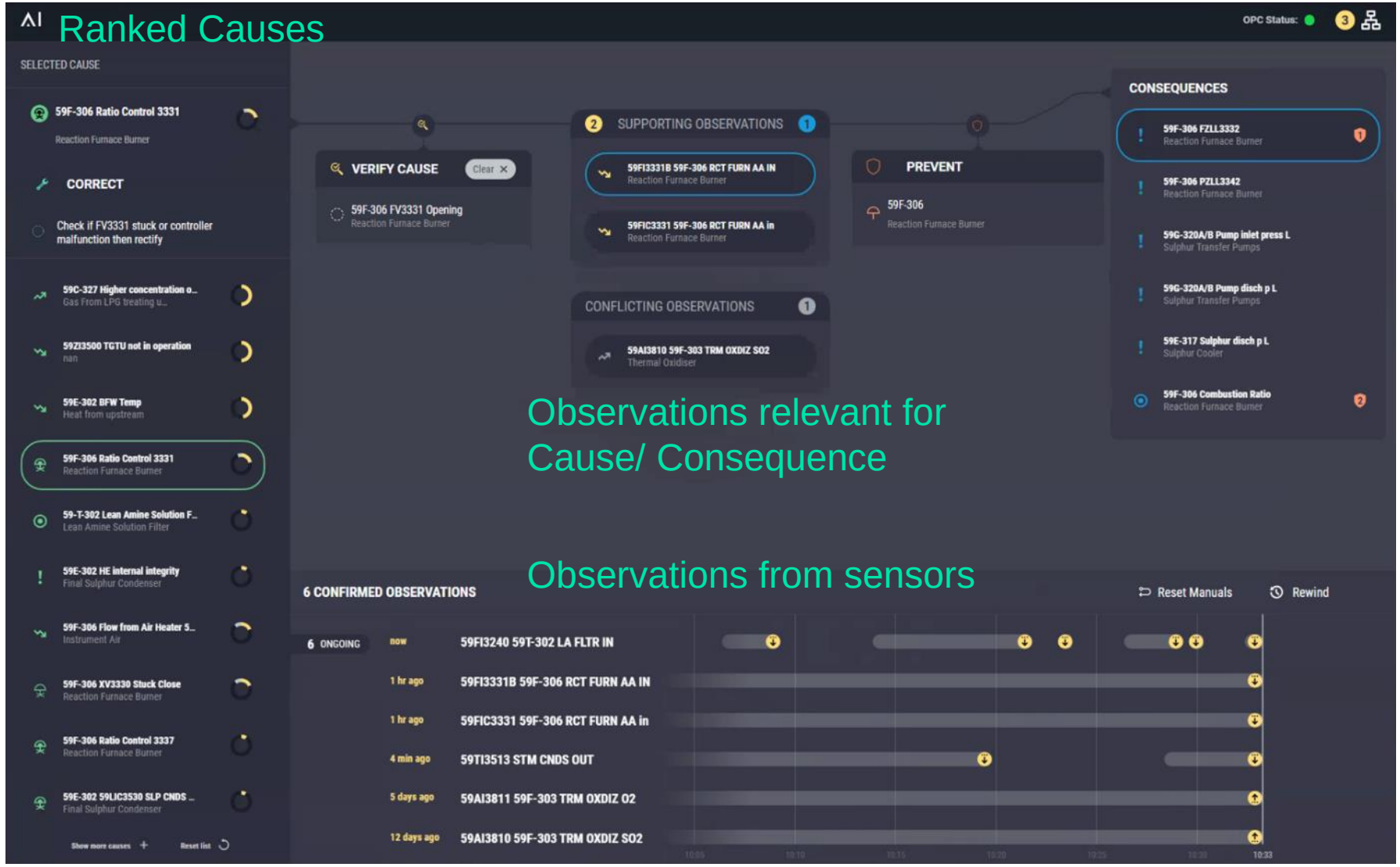
- Uses same digital twin of the plant using MFM
- Connects to the plant SCADA
  - Reads signals from sensors and detects deviations
  - Reasons causes & consequences with discrimination
  - Provides actionable advice for troubleshooting
- “Deviations” occur before “actual alarms” go off
- Discrimination based on probabilistic weighting





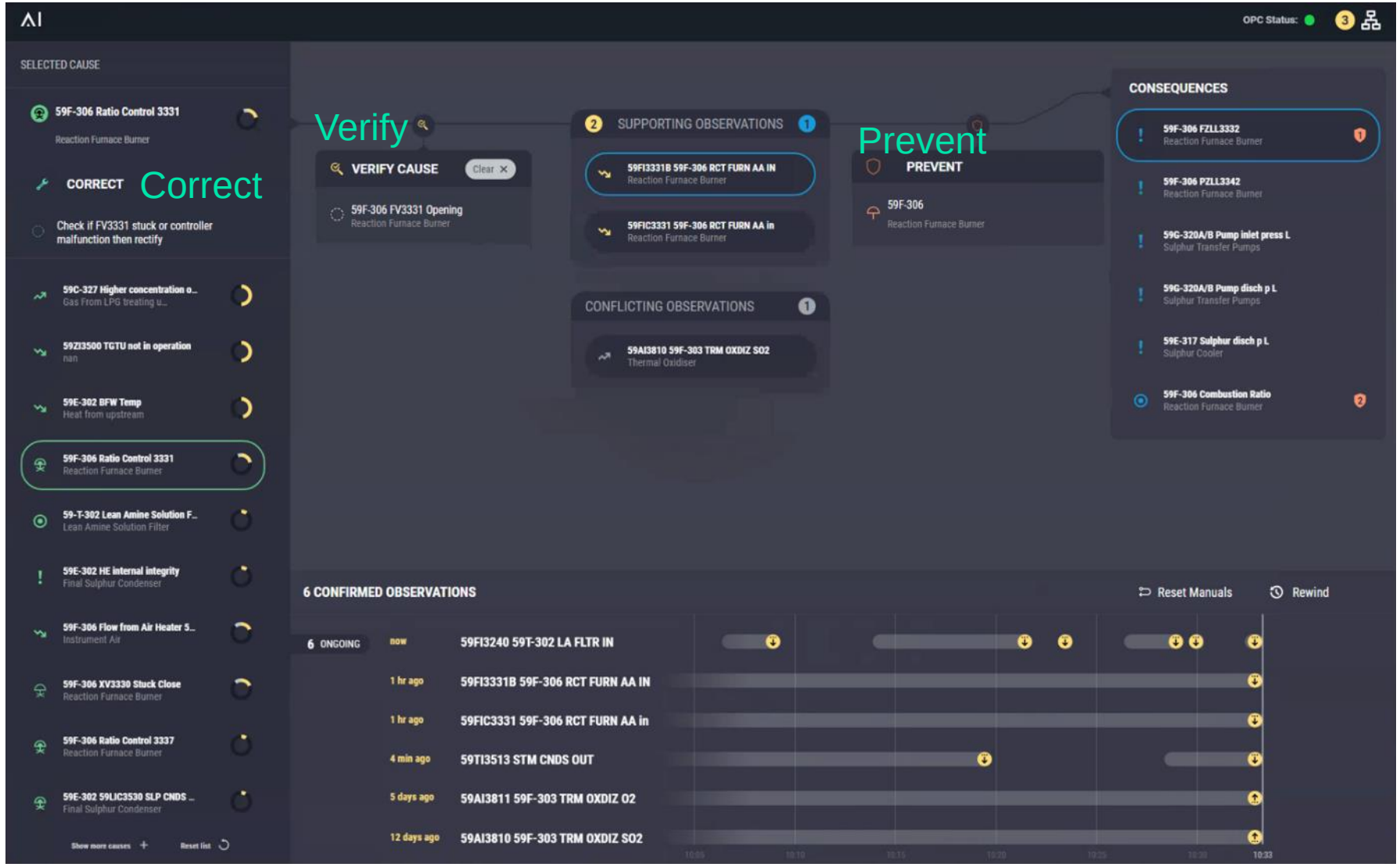
Stauffer, T., Sands, N., and Dunn, D., “Get a life(cycle)! Connecting Alarm Management and Safety Instrumented Systems” ISA Safety & Security Symposium April (2010).

CRA – Overview of HMI



Ranked Consequences

CRA – Overview of actionable advice (counter measures)



Case study at SRU in Middle East Refinery

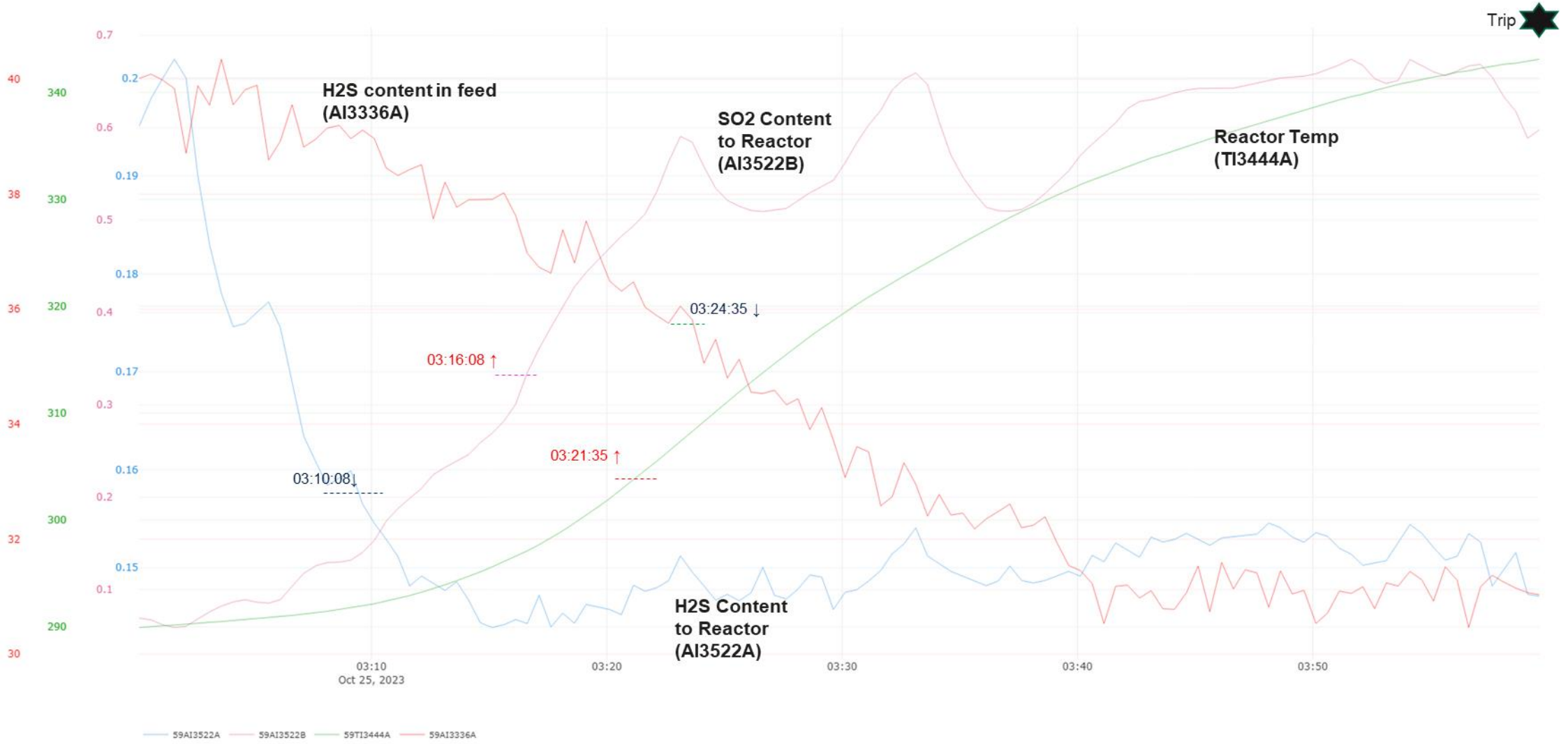
Process Description

- SRU receives acid gas feed from 4 upstream plants
- The feed goes to a reaction furnace; air is controlled to partially convert H2S to SO2
- Then feed Claus reactors produce elemental sulphur by reacting H2S with SO2
- Tail gas goes to Reduced Gas Regenerator (H2) and then to Hydrogenation Reactor

Incident Description

- Plant tripped because high high temperature in the Hydrogenation Reactor
- The root cause for the trip was low H2S content in feed
- Low H2S feed to reaction furnace, air flow control saturates and, excess H2S is converted into SO2, leading to low H2S and high SO2 content in tail gas
- Catalyst in Hydrogenation Reactor is sensitive to SO2, high SO2 feed yields high temperature
- Operators wasted time and efforts reducing the temp in reactor rather than addressing the root cause

Case study at SRU in Middle East Refinery



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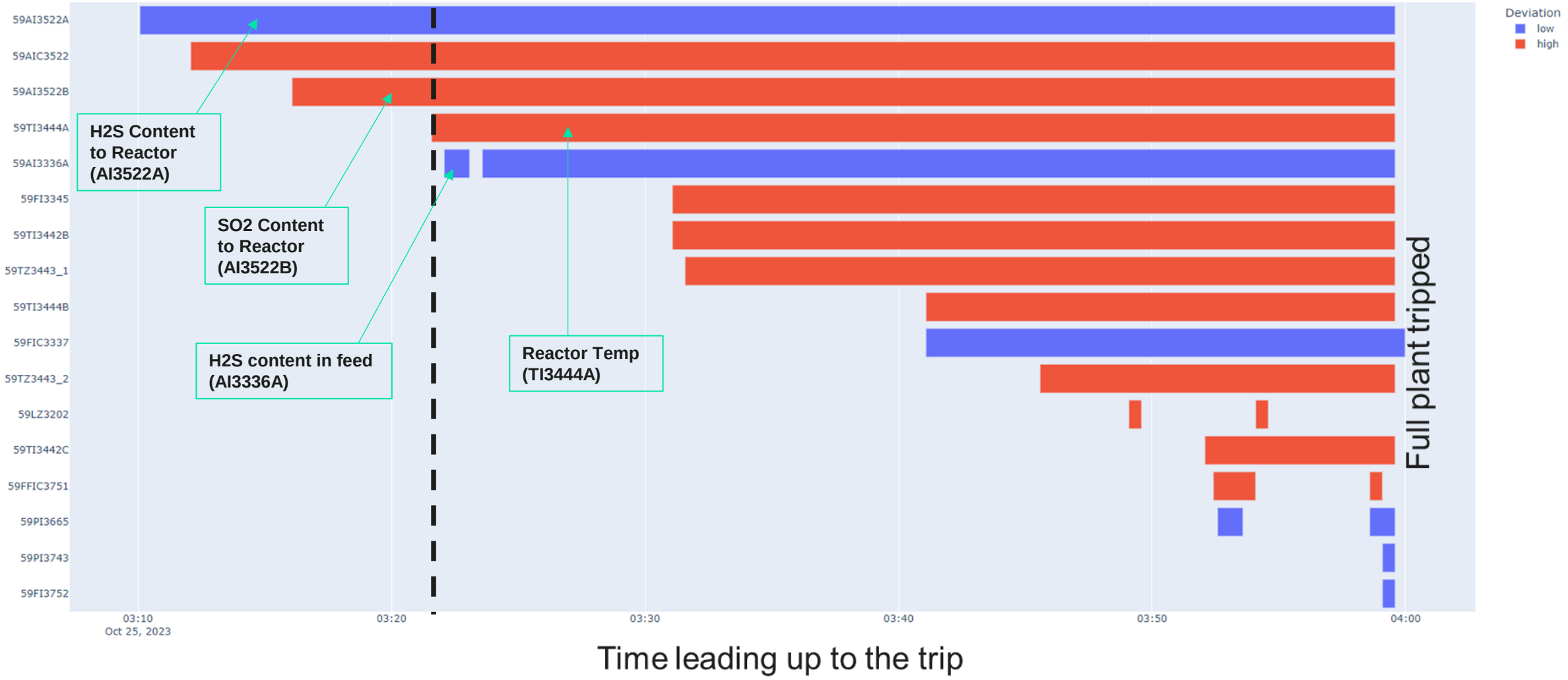


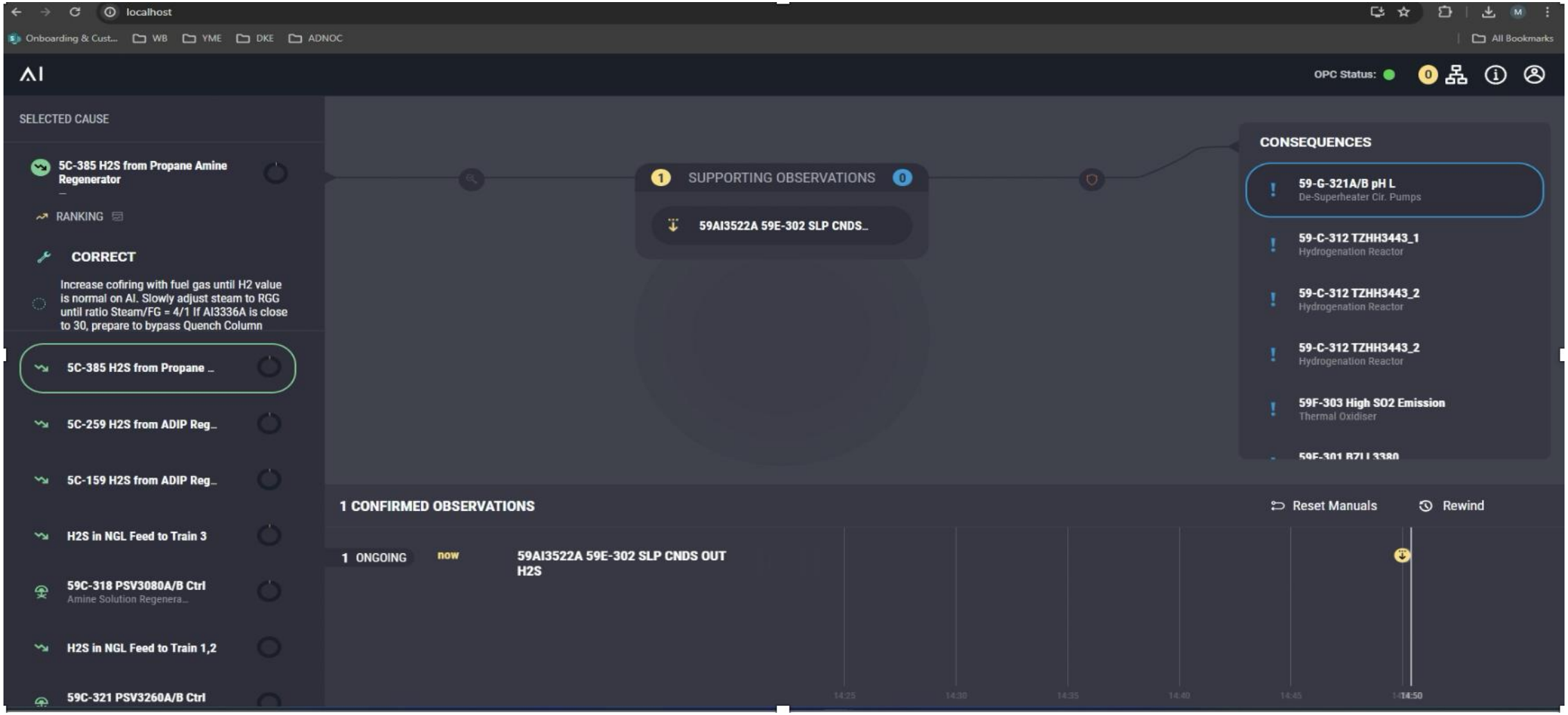
Case study at SRU in Middle East Refinery

- CRA model was created and running but not in the Control Room (Process Eng Station)
- Process upset was detected 50 minutes before the trip
- Actual root causes were shown as the “most probable” 36 minutes before the trip

Case study at SRU in Middle East Refinery

Time leading up to the trip

Case study at SRU in Middle East Refinery



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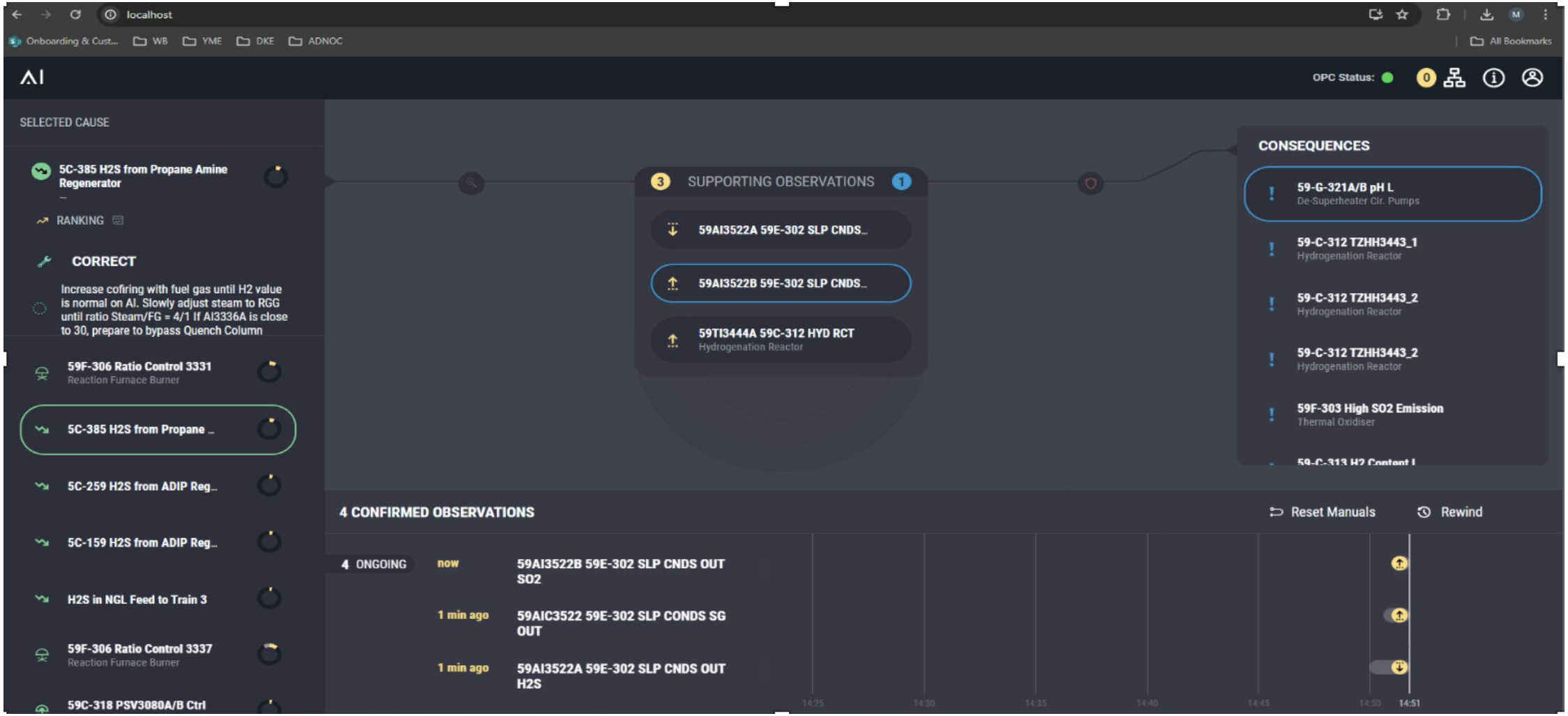

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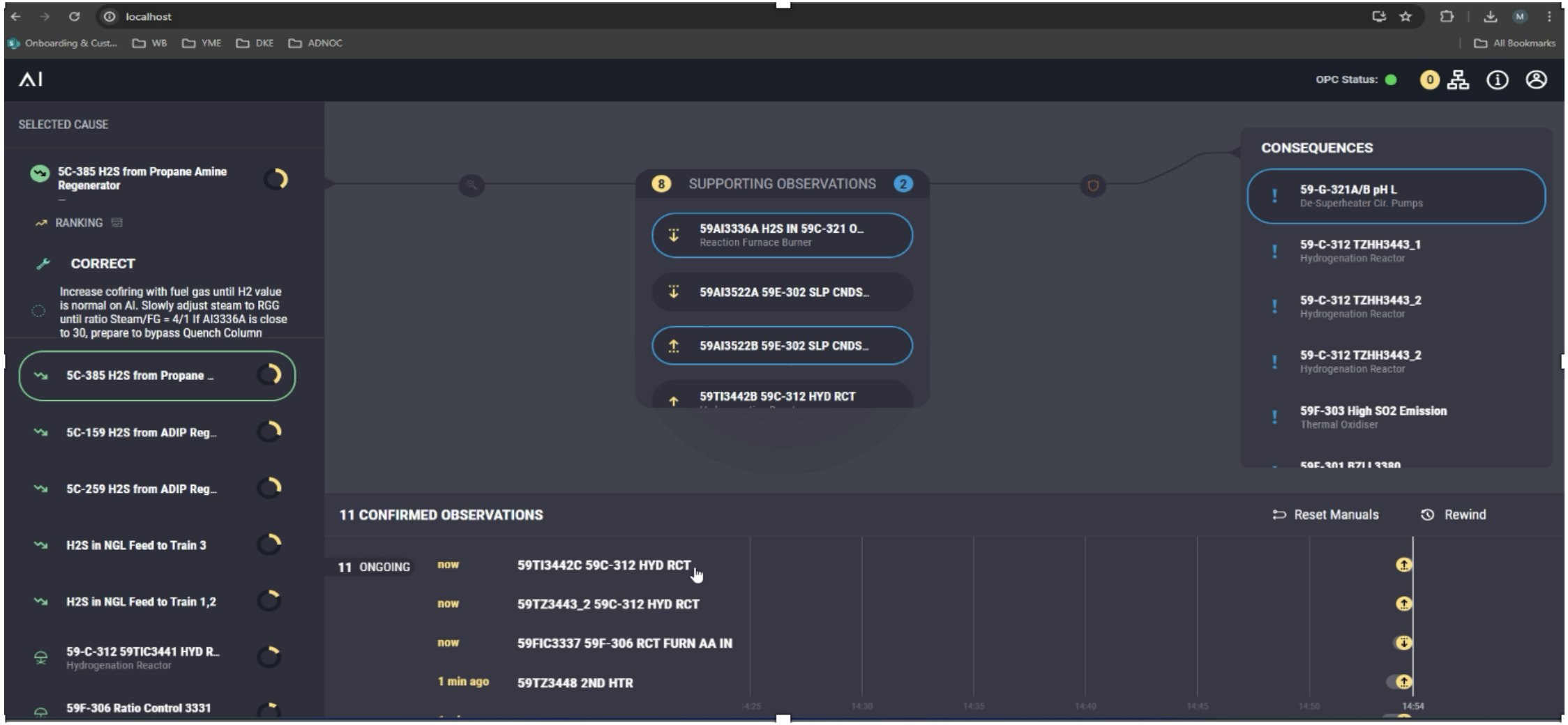

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Thank you

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